A METHODOLOGICAL APPROACH TO ASSESS ALVEOLAR RIDGE PRESERVATION PROCEDURES

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BRANCH II
DEPARTMENT OF PERIODONTICS

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CERTIFICATE

This is to certify that this dissertation titled **"A METHODOLOGICAL APPROACH TO ASSESS ALVEOLAR RIDGE PRESERVATION PROCEDURES"** is a bonafide record of work done by **Dr.VENKATESWARI**, under our guidance and to our satisfaction, during her postgraduate study period of 2012-2016.

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ABSTRACT

Aims: Multiple surgical protocols using biomaterials have been proposed to limit the typical post-extraction bone resorption. However, because of the heterogeneity of the studies, particularly the differences in assessment methods, it is difficult to determine the superiority of one technique over another. The objective of this study was to describe a new radiographic method to draw a map of alveolar bone remodelling after alveolar ridge preservation procedures to compare different surgical techniques more accurately. The newly developed measuring method was applied to a case series describing a specific preservation technique.

Materials and Methods: Five extraction sites (in 3 patients) located in the upper anterior maxilla were treated with osseograft and rubber dam as a non-resorbable membrane. A radiographic three-dimensional assessment of the hard tissues was performed at baseline and 3 months after the procedure. Standardized horizontal measurements were taken at three corono-apical levels (2, 5 and 8 mm) and at three mesio-distal levels (mesial, centre and distal) in the buccal and palatal aspects. Vertical measurements were also recorded in nine regions superior to the alveolar crest. The measurements were performed by two independent observers and intra- and inter-observer effects were evaluated.

Results: No inter- and intra-observer effects were found when analysing the measurements from these two observers. The horizontal dimension of the crest decreased by 2.09mm (24.60%) in the cervical regions (2mm level), decreased moderately, by 1.25mm (26.10%), at the 5 mm level and decreased very little, 0.964mm (36.10%), at the apical (8 mm) level. The losses were always significantly higher in the buccal than in the palatal aspect. Vertical bone resorption was homogeneous in the nine measured regions.

Conclusion: The radiographic measuring methodology proved to be reproducible. It can be applied in other clinical settings. It successfully assessed the alveolar ridge preservation technique (Osseograft and Rubberdam). It was observed that the remodelling of the alveolar process was not uniform after the socket preservation, and a complete inhibition of the bone remodelling was not achieved during alveolar socket preservation procedures.

Key words: alveolar bone preservation; biomaterials; CT scan; extraction socket; socket preservation.

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LIST OF ABBREVIATIONS

AP	-	Alveolar process
G	-	Gingiva
PL	-	Periodontal ligament
RC	-	Root cementum
AB	-	Alveolar bone
ABP	-	Alveolar bone proper
DF	-	Dental follicle
DP	-	Dental papilla
ARP	-	Alveolar ridge preservation
DFDBA	-	Demineralized freezed dried bone allograft
FDBA	-	Freezed dried bone allograft
RD	-	Rubber dam
PTFE	-	Polytetrafluroethylene
GTR	-	Guided tissue regeneration
CT	-	Computed tomography
CBCT	-	Cone beam computed tomography
DBBM	-	Deprotinized bovine bone matrix
BL	-	Bucco-lingual
AC	-	Apico-coronal
ADM	-	Acellular dermal matrix
EXT	-	Extraction
TCP	-	Tri calcium phosphate
PFGF	-	Plasma derived growth factor
Tx	-	Treatment
RhBMP-2	-	Recombinant bone morphogenic protein-2
ACS	-	Absorbable collagen sponge

The alveolar process (AP) is a tooth-dependent tissue that develops in conjunction with the eruption of the teeth. The tooth is anchored to the jaws via the bundle bone into which the periodontal ligament fibres invest. The volume as well as the shape of the alveolar process is determined by the form of the teeth, their axis of eruption and eventual inclination.

Tooth extraction is one of the most common dental procedures. Generally, the extraction socket heals uneventfully. The size of the residual ridge is reduced most rapidly in the first 6 months, but bone resorption activity in the residual ridge continues throughout life at a slower rate resulting in the removal of large amounts of jaw structure.[1]

Limited bone volume may lead to less successful restorative treatment outcomes using implants which originally aimed to restore the aesthetics and function of the natural dentition. The maintenance of adequate alveolar bone height and width or regeneration of alveolar bone is crucial for the implant placement not only for the support of the prosthesis but also for the aesthetic outcome.[2] Bone graft materials have been used to facilitate bone formation within a given space by occupying that space and allowing the subsequent bone growth to take place.[3]

Controlled clinical studies have documented an average of 4.4 mm of horizontal and 1.2 mm of vertical bone resorption 6 months after tooth extraction.[4-6] Various materials (Bioabsorbable membrane made of glycolide and lactide polymers, Nonabsorbable expanded polytetrafluroethylene (ePTFE) membranes, Absorbablc hydroxyapatite, Anorganic bovine bone) have been used to prevent or minimize ridge collapse after tooth extraction in an attempt to improve implant placement and the subsequent aesthetics of the final implant prosthesis.

The assessments of socket preservation procedures are not easily comparable because of difference in surgical protocols, type of assessment methods and different observation times. The reference points were also highly variable that include adjacent teeth, acrylic guides or titanium pins. The assessment also suffers from a lack of precision because most of the studies used a probe or a calliper and were based on a limited number of measurements, which poorly reflected the three dimentional (3D) aspect of bone resorption. Moreover, these direct intra-oral measuring techniques involve atraumatic flap elevation at the time of extraction and at the time of implant placement.

Modern radiology provides highly accurate images at lower X-ray doses and imaging software allows a more precise and reproducible assessment of the three-dimensional changes in the alveolar crest. In an attempt to circumvent the lack of precision of direct intra-oral measurements, a new methodological approach that is based on (CT) scans which was introduced and developed in the study done by *Lambert et al* in 2012.[7] Based on the above mentioned study, this study aims to assess three dimensional preservation of alveolar ridge using CT scans.

Aim of the study

To draw a map of bone remodelling patterns after alveolar ridge preservation procedures. A methodological approach was applied to a case series describing a particular alveolar ridge socket preservation technique, which uses Osseograft combined with rubber dam as a non resorbable membrane.

Objectives of the study

- To assess the amount of alveolar bone loss quantitatively, after 3 months of socket preservation procedures.
- Three dimensional measurement of bone loss at 3 levels; 2mm, 5mm and 8mm of the alveolar socket from alveolar crest.
- To compare the difference in bone loss in the buccal and palatal side of the socket.
- To compare the difference in bone loss in the apical, middle and coronal third of the socket.

ALVEOLAR BONE

The AP is defined as the parts of the maxilla and the mandible that form and support the sockets of the teeth.[8]

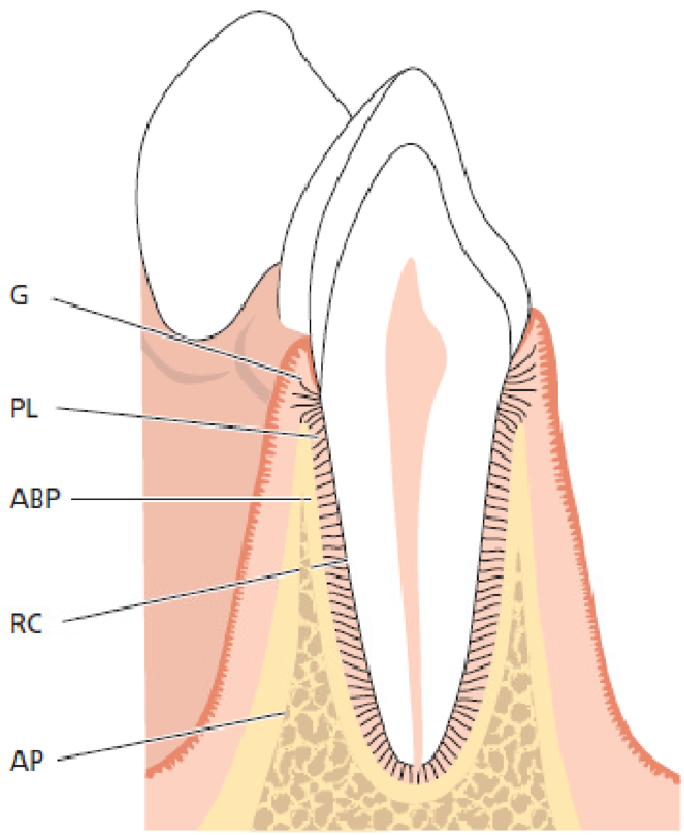

Fig.1. Periodontium (peri = around, odontos = tooth) comprises the following tissues. (1) The gingiva (G), (2) the periodontal ligament (PL), (3) the root cementum (RC), and (4) the alveolar bone (AB). The AB consists of two components, the AB proper (ABP) and the AP. The ABP, also called "bundle bone", is continuous with the AP and forms the thin bone plate that lines the alveolus of the tooth.[8]

The AP is the bone of the jaws containing the sockets (alveoli) for the teeth. It consists of outer cortical plates (buccal, lingual, and palatal) of compact bone, a central spongiosa, and bone lining the alveolus (AB).

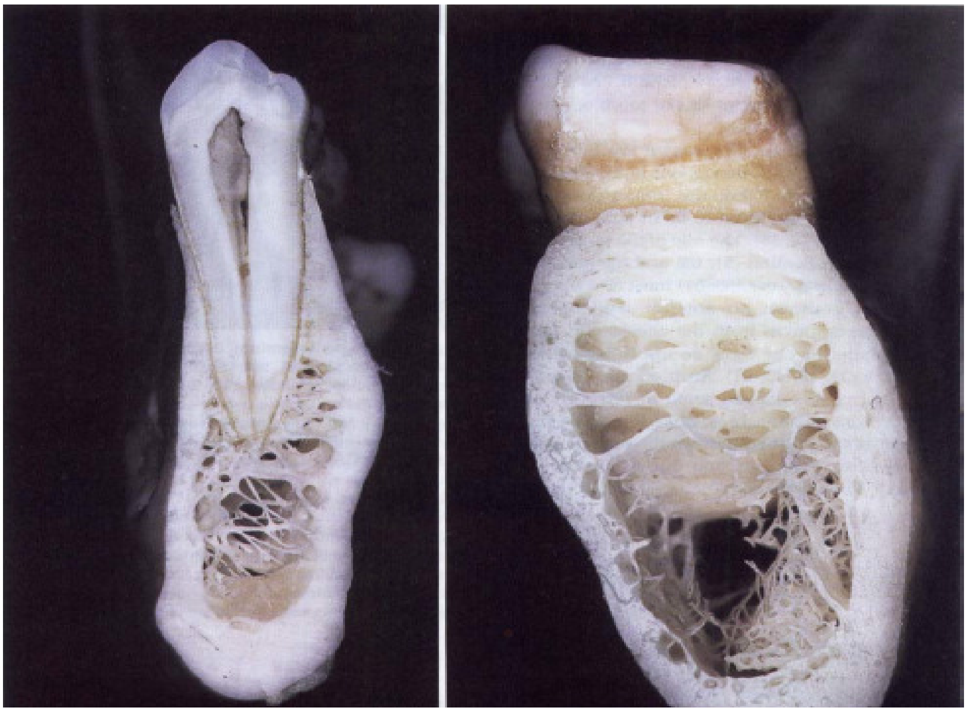

Fig.2. Human mandible, buccooral section through the bicuspid, shows cortical and cancellous bone

The cortical plate and bone lining the alveolus meet at the alveolar crest. The bone lining the socket is specifically referred to as bundle bone because it provides attachment for the periodontal ligament fiber bundles. The cortical plates consist of thinner in the maxilla and thickest on the buccal aspect of mandibular premolars and molars. The trabecular bone occupying the central part of the AP also consists of bone dispersed in lamellae, with Harversian systems present in the larger trabeculae. The Yellow marrow, rich in adipose cells, generally fills the inter-trabecular spaces, although sometimes there can also be some red or hematopoietic marrow.[9] In anterior teeth region, cortical and AB are fused together, so in between trabecular bone is absent. Bundle bone consists of intrinsic and extrinsic fibers; intrinsic fibers are arranged parallel and extrinsic fibers are perpendicular to its surfaces.

Because the tooth is constantly making minor movements and AB must respond to the functional demand placed on it by the forces of mastication, the bone of the socket wall is constantly remodeled and its structural organization varies along the wall. The presence of an

AB along the entire tooth socket separates the supporting bone anatomically and functionally from the periodontal ligament. The organization of the AP is yet another example of structure–function relationship in the periodontium. Compare to other anatomical sites, AB is distinctive because it turns over very rapidly and it is lost in the absence of a tooth. These two characteristics suggest that local regulatory mechanisms are particularly important in the case of AB. They also clearly demonstrate the interdependence of the periodontal tissues and underline the important fact that the periodontal tissues function together as a unit.[10]

The AP develop and undergo remodeling with the tooth formation and eruption hence they are tooth-dependent bony structures. Therefore, the size, shape, location and function of the teeth determine their morphology. The ABP is 0.1 to 0.4 mm thick and is consisted of a Harversian system, lamellated and bundle bone. The coronal and apical regions of the ABP have a sieve-like structure. These openings connect the periodontal ligament to the bone marrow spaces and correspond to Volkmann's canals through which blood vessels, lymphatic vessels and nerve fibers pass.[11]

AB, which has interdependence with the dentition, has a specialized function in the support of teeth. While there are architectural specifications for AB that relate to its functional role, the basic cellular and matrix components are consistent with other bone tissues. Similarly, the cellular activities involved in the formation and remodeling of AB and the factors that influence these cellular processes are common to bone tissues generally. However, specific features, such as the rate of bone remodeling, may be unique to AB and may be important for its adaptability. Many of the factors regulate bone remodeling appear to exert their effects either directly or indirectly through genes, which have become important targets for developing pharmacological and clinical strategies to regulate the rate of bone formation and resorption that will be important for maintenance of a healthy periodontium.[12]

The dental papilla (DP) and dental follicle (DF), the non-ectodermal components of the tooth buds, are formed by concentration of neural crest ectomesenchymal cells.[11]

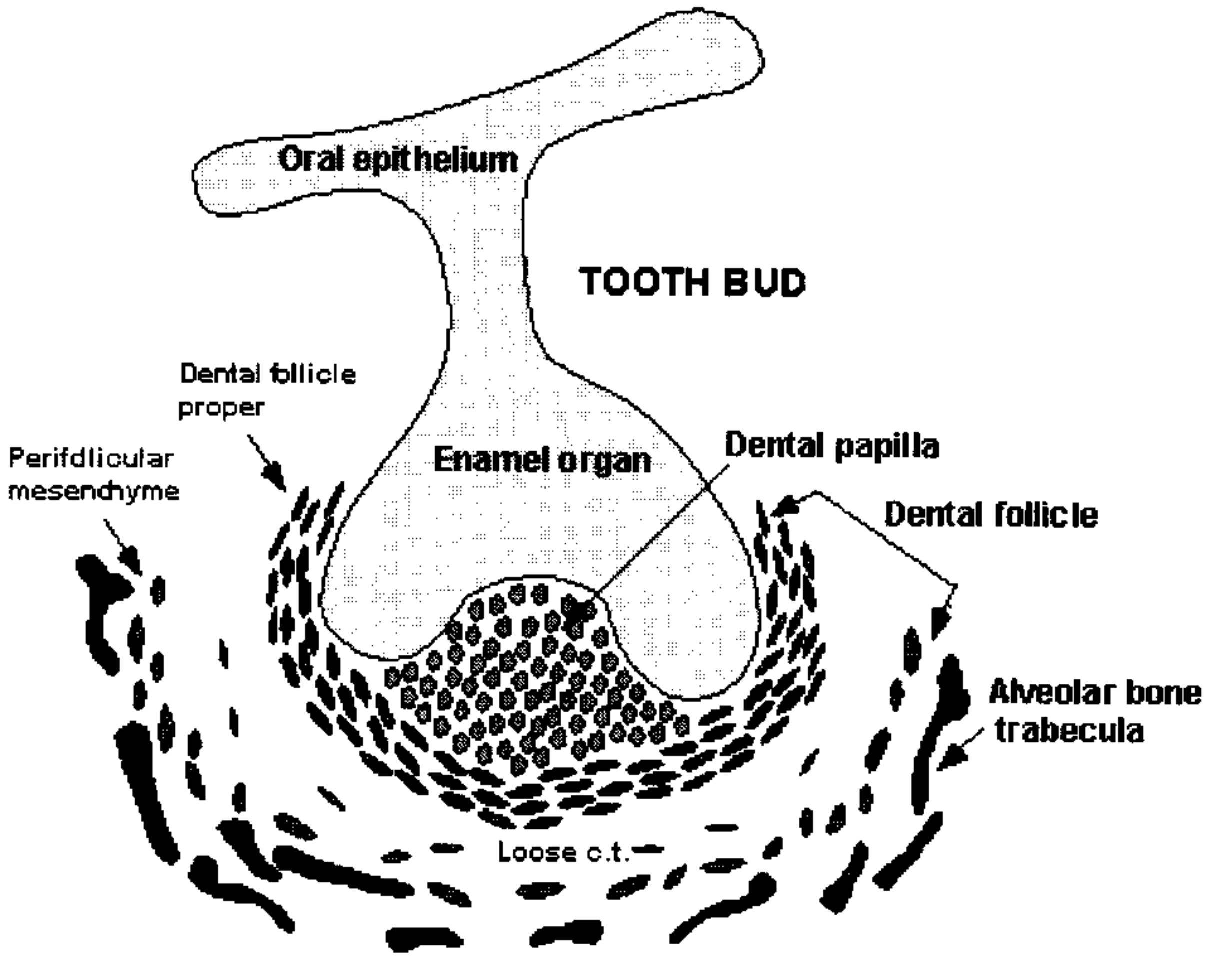

Fig.3. Diagrammatic view of a developing tooth at the cap Stage

DF gives rise to cementum, periodontal ligament and AB. Anatomically, the DF consists of the DF proper, a rather well-defined band of cells juxtaposed to the DP and the convex outer surface of the enamel organ; and the perifollicular mesenchyme, a more loosely defined population of cells bordering the developing bony trabeculae which partly surround the tooth bud. A poorly populated zone of loose connective tissue separates these layers. The loose connective tissue interface creates a natural cleavage plane during tooth bud extirpation. The DF proper remains attached to the tooth bud, while the perifollicular mesenchyme remains associated to the bony trabeculae.

The DF proper contains all the precursors needed for cementum, bone and periodontal ligament formation, migrating fibroblasts from the perifollicular mesenchyme proliferate during root development to contribute to the pool of periodontal ligament fibroblasts. The perifollicular mesenchyme and perivascular cells may also gives rise to osteoblasts of the AB.[11]

The maxilla and mandible of subdivided into two portions:

(a) The AP that involves in housing the roots of erupted teeth.

(b) The basal body that does not involve in housing the roots.

The AP consist of the thin ABP that forms the alveolar wall of the tooth socket, the inner and outer cortical plates, and spongy bone between the ABP the cortical plates. The coronal and apical regions of the ABP have a sieve-like structure. These openings connect the periodontal ligament to the bone marrow spaces and correspond to Volkmann's canals through which blood vessels, lymphatic vessels and nerve fibers pass.

At the late bell stage, bony septa and bony bridge start to form, and separate the individual tooth germs from another, keeping individual tooth germs in clearly outlined bony compartment at this stage, the DF surrounds each tooth germ, which is located between a tooth germ and its bony compartment. Even prior to root formation, the tooth germs within bony compartments show continued bodily movement in various directions to adjust to the growing jaws. This movement causes minor remodeling of bony compartment through bone resorption and deposition of new bone.

The major changes in the AP begin to occur during tooth eruption. As the roots of teeth develop, the AP increase in height. Also, cells in the DF start to differentiate into periodontal ligament fibroblasts and cementoblasts responsible for the formation of the periodontal ligament and cementum, respectively. At the same time, some cells in the DF also differentiate into osteoblasts and form the ABP formation of the ABP is closely related

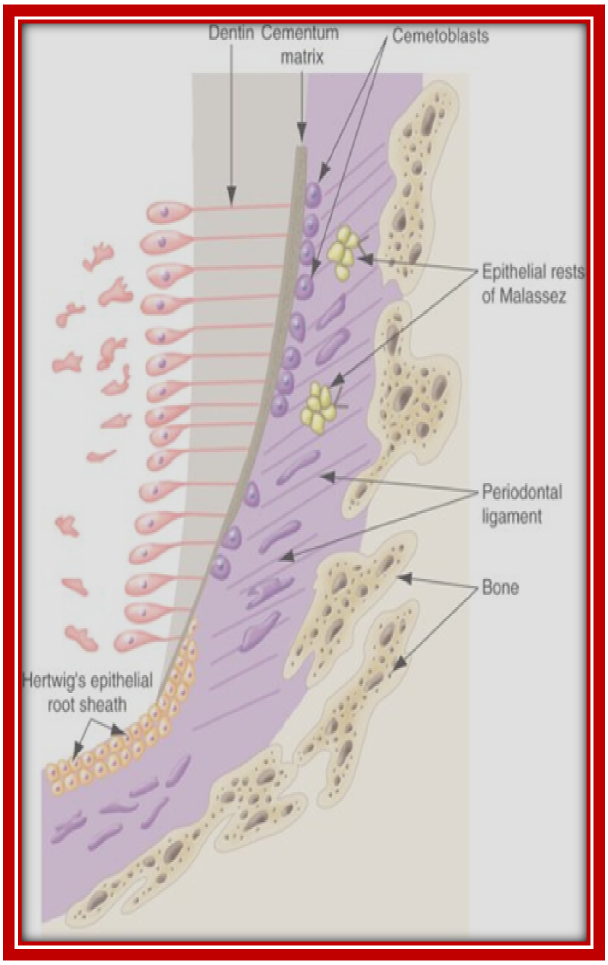

Fig.4. Maturation phase

to the formation of the periodontal ligament and cementum during root formation and tooth eruption. Thus, the size and shape of the individual developing tooth roots determine the overall structure of the ABP.

REMODELING OF THE ALVEOLAR PROCESSES DURING TOOTH ERUPTION

The tooth germs develop within the AP, the AP has already grown over the occlusal plane of the developing tooth. So for successful tooth eruption, there must be bone remodeling. In order for the developing tooth to escape from the AB, a gubernacular canal must be widened by osteoclastic bone resorption.

At the same time, new bone formation seen at the base of the bony crypt, this is important to produce eruption force during tooth eruption. The presence of the DF was essential for bone resorption during eruption and new bone formation in apical side, and also proteinase activity in the follicular connective tissue peaks at initiation of tooth eruption. Monocytes containing tartrate-resistant acid phosphatase, an indicator of lysosomal activity, invade the connective tissue of the DF early in tooth development and during tooth eruption.

These cells are believed to be osteoclast precursors that play an important role epidermal growth factor upregulates the production of colony-stimulating actor-1 via its ability to stimulate the cells of the reduced enamel organ to make interleukin-1α.[11]

FUNCTIONS OF THE ALVEOLAR PROCESSES

The general functions are to house the roots of teeth and to absorb and distribute occlusal pressures generated during tooth contacts. Their most important and unique function is to anchor the roots of teeth to the alveoli, which is achieved by the insertion of Sharpey's fibers into the ABP.[11]

TOOTH EXTRACTION

Tooth extraction is one of the most common dental procedures. Usually, the extraction socket heals uneventfully. During healing resorption of alveolar bone takes place the greatest amount of bone loss is in the horizontal dimension and occurs mainly on the facial aspect of the ridge. There is also loss of vertical ridge height, which has been described to be most pronounced on the buccal aspect. This resorption process results in a narrower and shorter ridge and the effect of this resorptive pattern is the relocation of the ridge to a more palatal/lingual position.[13] The defect resulting from the loss of a tooth may be complicated by previous bone loss due to periodontal disease, endodontic lesions, or a traumatic episode. The situation becomes even more compromised when the alveolus has lost walls or height. Loss of AB may have occurred before tooth extraction because of periodontal disease, periapical pathology, or trauma to teeth and bone. The size of the residual ridge is reduced most rapidly in the first 6 months, but bone resorption activity in the residual ridge continues throughout life at a slower rate resulting in the removal of large amounts of jaw structure. Morphologic changes in extraction sockets have been described by cephalometric measurements, study cast measurement, radiographic analysis and direct measurements of the ridge following surgical re-entry procedures.[14]

Sufficient AB volume and favourable architecture of the alveolar ridge are essential to obtain optimal functional and aesthetic prosthetic reconstructions. Therefore, knowledge about the healing process at extraction sites, including contour changes caused by bone resorption, is essential for treatment planing.[1]

EXTRACTION SOCKET HEALING SEQUENCE

AB ridge changes can occur for various reasons: pathological changes of chronic periodontitis, traumas (including the extraction of a tooth), developmental disorders (such as alveolar cleft), and long term edentate alveolar crest, the mechanical effect of the alveolar crest, jawbones (upper or lower), tooth shape and others. According to the resorption the effect of factors can be divided into: anatomical, prosthetic, functional, and metabolic factors.[15]

CHANGES AFTER TOOTH EXTRACTION

Changes in AB ridge after a tooth extraction are inevitable. It is a natural process where the models have been documented while studying animals and humans. The size of the alveolus affects the rate of healing wider alveolar sockets require more time to bridge the defect.[16] Bone height and width usually undergo dimensional changes after extraction of a tooth. Bone does not regenerate above the horizontal level of alveolus crest, i.e. its height cannot increase after the healing. After the healing event, the crest of the residual ridge shifts lingually when compared with the original position of the teeth before extraction and from the lateral aspect, the residual ridge often forms a concavity. The bigger the damage to the facial wall, the bigger deformation of the contour occurs.[17]

INTRA ALVEOLAR CHANGES

- When a tooth is removed the entire socket is filled by blood clot which is formed within 24 hours within 2 to 3 days, the clot changes and start to form a granulation tissue.[18]
- After 4 to 5 days the granulation tissue covers AB ridge usually, and the epithelium proliferates along the soft tissue periphery covering the granulation tissue.
- By the end of 1 week, osteoid is evident at the apical portion (at the base) of the socket as uncalcified bone spicules; a vascular network is formed and young connective tissue is found.
- After 3 weeks the alveolus is filled with connective tissue, while osteoid begins to mineralize, and the socket surface is covered with epithelium.
- After 6 weeks trabecular bone formation is observed. The bone deposition in the socket is seen well after two months.
- Bone deposition retards after 4 to 6 months, but continues to occur for a few months.

EXTRA ALVEOLAR CHANGES

Anatomically buccal AB ridge is thinner than palatal. Alveolar sockets are lined by cortical bone. It is important that lamina dura forms AB ridge which is a part of periodontium. When a tooth is extracted – periodontium is destroyed so resorption of bundle bone follows. In addition, resorption increases because of a mucoperiosteal flap elevation.

- After mucoperiosteal flap was elevated and a tooth extraction was done, in one week it is observed a significant increase in both quantity of osteoclasts on the inner and outer sides of the alveolar walls.

- Two weeks later, osteoclasts are present in the exposed area of the alveolar related ridge, the young connective tissue and bundle bone are replaced by immature bone intermittently.
- During the four-week period of monitoring a number of osteoclasts in the buccal site and AB ridge area and crest are seen, immature bone is replaced by related trabecular bone.
- In 8 weeks cortical bone covers the alveolar socket. External alveolar walls and crest are still under resorption (the resorption of buccal surface is greater). Lately alveolar ridge changes during a 12 months period after a tooth extraction were set as follows.
- The width of the alveolar ridge was decreased by 50 per cent (approximately from a mean of 12 mm to 5.9 mm.
- The two-thirds width reduction of the alveolar ridge occurs during the first 3 months.
- The alveolar walls loose vertical dimensions (0.7-1.8 mm). (buccal site more than lingual).
- The bone level parameters (the height and width) of the extracted tooth rather than the bone level of the adjacent teeth influence the level to which the bone crest heals after extraction.
- Only slight changes in soft tissue height took place in the place of in the crestal part of the AB ridge.

During the first year after the extraction bone resorption was 10 times higher. Following tooth loss, change in function influences the edentulous AB. It is found that the resorption of edentulous alveolar ridge in a case of removable dental prosthesis is four times faster in mandible.

The faster resorption is caused by a strong biting force for the smaller surface of the lower jaw alveolar crest and due to peculiarities in bone structure. Edentulism for a long period results in thin alveolar ridge will covering the basal jaw area.[19]

DIMENSIONAL CHANGES IN DAMAGED EXTRACTION SOCKETS

The rate and pattern of bone resorption may be altered if pathologic or traumatic processes have damaged one or more of the bony walls of the socket. It is likely in these circumstances that fibrous tissue may occupy a part of the socket, thereby preventing normal healing and osseous regeneration from taking place. There are insufficient data on the differences in rates and patterns of the healing of intact versus damaged extraction sockets.[20]

DIMENSIONAL CHANGES OF THE MUCOSA

It is generally believed that the form of the mucosa closely follows the changes in the underlying bone. An apical shift in the coronal bone may be followed by a similar shift in the position of the mucosa. However, in a study comparing healing of undisturbed sockets with healing of sockets grafted with freeze-dried bone allograft and a collagen membrane, the thickness of the mucosa at the buccal aspect of the ridge crest increased by 0.4 mm after 4 months in the control group. The grafted group showed a loss of tissue thickness of 0.1 mm.

The differences between test and control groups were significant. Although complete epithelialization of the socket is established by the fifth week of healing, organization and maturation of the collagen in the underlying lamina propria takes longer to occur. Matrix synthesis begins at 7 days and peaks at 3 weeks; this is followed by a continuous process of maturation until complete tensile strength is restored several months later.[21] Lack of tensile strength in the mucosa of healing extraction sockets may result in wound dehiscence. Dehiscence rates of 5% to 24% have been reported at delayed implant sites treated with both resorbable and nonresorbable membranes, despite the presence of adequate tissue volume to achieve primary closure.[22]

An atraumatic tooth extraction is very important for preservation of AB volume and surrounding soft tissues. Optimal results are received with atraumatic tooth extraction. The results are even better when additional alveolar preservation. Prior to extracting the tooth, a full clinical and radiographic evaluation must be performed. Anatomical features of the tooth are assessed. Additional difficulties may be caused by long and/or divergent, bulbous roots, root fusions, big curvedness, dimensional changes of periodontal ligament space or even dissolution (ankylosis), proximity of anatomically significant structures (maxillary sinus floor, mandibular canal).

LOOSENING OF SOFT TISSUE ATTACHMENT FROM THE TOOTH

Loosening of the soft tissue attachment from the tooth is done with elevators, luxators, scalpel or periotome. These are used for trying to preserve the interdental papillae and breakdown of periodontal fibers.

TOOTH LUXATION AND EXTRACTION

It is done using forceps, elevators avoiding marginal AB ridge damage. To ease loosening (luxation) of a tooth some instruments can be used. Even though there are extra instruments the extraction should be done with the forceps. The tooth to be extracted often breaks (fraction of the roots about 44.76%, crown fraction about 34.21%, crown and root fracture about 1.32%).[23] It should be taken into account. It is recommended during atraumatic tooth extraction to section the tooth by applying straight or angled hand pieces with fixed prolonged diamond or hard metal burrs cooling with saline abundantly. Size of the bur depends on the size of the tooth part to be sectioned. These actions should be performed trying to avoid bone and soft tissue damages. Removal of dental hard tissues needs to be minimal but not the essential action for the atraumatic teeth extraction. Dividing can ease, without fracture to remove the tooth using other instruments. Some authors suggest removing entire crown and later section roots (if a tooth is multi-rooted), while others suggest sectioning of roots without entire crown removal.[24] It is always recommended to remove sectioned, diverged tooth-roots separately. Non loosened root is sectioned using a bur into several parts later extracted using elevators. Ankylosed root part can be removed by using a small diamond bur preserving periodontal area tissues and later applying thin elevators. If there is noticed broken, loosen wide root canal for the extraction is enough the endodontic hand instruments of appropriate size can be used while they are implanted in to the canal. Minor loosen teeth fragments may be removed by washing them under saline stream or suction. Broken root fragments must be extracted. Exceptionally root tip can be left according to present conception (especially there are close important anatomical structures, when extracting an impacted wisdom tooth or tooth when will not be inserted dental implant).[24] This exception can be applied only if the assessment concludes that the risk of fragments retrieval is greater than non-removal from alveolar socket. Absolute requirements: fragments of less than 4-5 mm deep in the bone, non-infected. It is believed that such fragments can be encapsulated or resorbed. Any left fragments or other infections causing debris cannot be left in the space of implantation.

CLEANING OF ALVEOLAR SOCKET

After performed tooth extraction damaged tissues (marginal, periapical), remnants of fragments need to be removed thoroughly by selected size periapical curette or dental excavator. If healthy tissues are damaged, extraction socket is recovering more difficult. If insufficient bleeding is present, the apical bundle bone walls should be perforated in several places by round bur with a slow handpiece. Insufficient haemorrhage of the socket causes more difficult healing.[25]

CLOT STABILIZATION

After the tooth extraction clot has no mechanical stability in alveoli of high range. It can be washed out with water, damaged mechanically. It can complicate alveolar healing process. Stability of clot and dental crest improvement especially when alveoli can be augmented can be done with the following material combinations: [19]

a) Surgical suture

b) Collagen

c) Polylactide/polyglycolide gel/sponge

d) Iobutyl cyanoacrylate

e) Temporary crown above the extraction socket.

RIDGE PRESERVATION

Prerequisites for successful implant therapy are integration of the implant, ideal implant position and appropriate hard and soft tissue contours. These require sufficient AB volume and favourable ridge architecture coupled with an appropriate surgical technique. However, following extraction of teeth the alveolar ridge resorbs, the rate of which may vary between sites and subjects. This may result in inadequate bone volume and unfavourable ridge architecture for dental implant placement.[26]

Alveolar ridge preservation (ARP) is defined as the procedure of arresting or minimizing the alveolar ridge resorption following tooth extraction for future prosthodontic treatment including placement of oral implants.[27] The purpose of ARP is to maintain favourable alveolar ridge architecture for future implant placement. The timing of implant placement varies and may influence the final functional and aesthetic outcomes. Following ARP, delayed implant placement is considered to allow time for bone formation within the extraction socket. ARP techniques may include the placement of different grafting materials with or without the use of membranes to preserve and minimise ridge resorption for optimising future implant placement.[28]

ARP is any procedure undertaken at the time of or following an extraction that is designed to minimize external resorption of the ridge and maximize bone formation within the socket. However, there are clinical situations where it is not advisable to undertake ARP at the time of extraction (e.g., in the presence of acute infection). In these situations, preservation of the ridge may be delayed by six to eight weeks.[22]

A recent consensus report suggested that minimal dimensional change occurs within six to eight weeks of an extraction.[22] ARP techniques are based on the principles of guided tissue /bone regeneration. Minimally traumatic tooth extraction, although tooth extraction is by necessity a traumatic procedure, the application of appropriate instruments with minimal force is recommended to limit damage to the hard and soft tissues.

DEBRIDEMENT AND DECORTICATION OF THE SOCKET

Sockets should be debrided to remove anything that may interfere with healing while others suggest that a round bur should be used to perforate the socket walls a number of times to allow greater access for blood vessels into the socket and any grafting material in an attempt to improve bony infill.[29] Conversely, it has been shown in an experimental study that retention of the periodontal ligament along the socket walls facilitated retention of the clot during the early stages of wound healing.[30] Thus, apart from removal of chronically inflamed tissue and foreign materials, extensive debridement or perforation of the socket walls may not be required.

COVERAGE OF THE SOCKET BY SOFT TISSUE

The literature is divided over whether soft tissue coverage of the socket at the time of extraction is necessary for optimum healing of the socket and aesthetics. Soft tissue coverage procedures may be considered to retain, stabilize and protect grafting materials. It is a critical step when using non-resorbable membranes. Many techniques have been suggested and include displacing neighbouring tissue to cover the socket, such as coronal advancement of a buccal flap, rotating grafts from tissue adjacent to cover the defect, or using free gingival or subepithelial connective tissue grafts.[31] Alternatively, the site may be left for six to eight weeks to allow healing and regeneration of mucosa over the socket. The added volume of soft tissue at this stage may facilitate optimum closure over the socket when ARP procedures are undertaken. In a similar manner, procedures allowing spontaneous soft tissue proliferation could be considered prior to extraction to increase soft tissue coverage, such as removing the crown and burying the remaining root.

The Bio-Col technique[32] involves the placement of an anorganic bovine bone graft (Bio-Oss) protected by a resorbable collagen sponge (Collaplug) and then allowing spontaneous epithelialization of the socket under a denture tooth or bridge pontic. However, there is a paucity of research evidence to support this technique. Mobilization of tissue can be a difficult procedure, but splitting the periosteum at the base of a flap is fairly straightforward and as a result may be the technique of choice. However, coronally advanced flaps need to be undermined and advanced a relatively great distance to completely cover an extraction socket. This may cause complications such as altering the mucogingival line and creating a shallow vestibule, either of which may require subsequent surgery to correct.

These problems may be avoided using a subepithelial connective tissue graft taken by a window or envelope procedure from the palate. This requires an appropriate donor site and sufficient coverage by soft tissue around the extraction socket to prevent necrosis of the graft in the initial phase of healing. The question remains that these techniques may increase soft tissue coverage, but do they result in increased bone fill when used on their own. Recent work in a dog model showed that this is not the case, a finding which may argue for a space filler to be placed in the socket or use of a membrane to maximize bone infill.[13]

BONE OR BONE-SUBSTITUTE GRAFTS ONLY: Many grafting materials have been used and these include autogenous bone, demineralized freeze-dried bone allografts (DFDBA), xenografts, bioactive glass, hydroxyapatite and calcium sulphate. Autogenous bone is thought of as the ‘‘gold standard”.[33]

Study compared demineralized freeze dried bone against autogenous bone in seven paired sites finding that after three months new bone was formed at sites where autogenous bone was placed, but not in six of seven sites using DFDBA. Common sites intra-orally to harvest autogenous bone are around the surgical site, ascending ramus, chin and tuberosity. Post-surgery the patient may experience considerable discomfort in the donor.[33]

Both the recent studies showed little new bone formed around DFDBA.[33,34] Another study used a common porous bovine bone graft (Bio-Oss) in 15 fresh extraction sockets, covering the graft with soft tissue and re-entering nine months later.[35] They reported that there was 82.3 per cent bone infill and all sites allowed ‘‘safe’’ insertion of fixtures. Histologic appearance showed a mixture of Bio-Oss and new bone formation, increasing in bone fraction apically. The use of a xenograft does not require a donor site, thus reducing morbidity following harvesting and simplifying the procedure. [33-35]

MEMBRANES ONLY

It is also possible to cover the socket to prevent ingress of soft tissue, thereby promoting maximal bony healing. Generally, there are two types of membrane used, resorbable and non-resorbable. The study investigated the use of ePTFE membrane to maintain the alveolar ridge after extraction.[4] Two sites in 10 patients were used, one site receiving a membrane and the other site as a control. All sockets were debrided and flaps displaced to cover the membrane and socket. Reassessment took place at six months, with significantly greater loss of bone height and width in the control group and more infill in the ePTFE group. However, 30 per cent of membranes became exposed and this resulted in similar results to the control group. Giving the high rate of exposure, this suggests the use of ePTFE membranes should perhaps be avoided.[4]

BONE GRAFTS AND MEMBRANES TOGETHER

The study reported on the use of tetracycline hydrated freeze-dried bone allograft and a resorbable membrane (Bio-Mend) compared to extraction alone in 24 patients. They replaced the flap coronally without complete socket coverage and reassessed four to six months later. Both groups lost ridge width, although the experimental group lost less width and had more bone infill. The test group sites were more suitable for implant placement, but all sites were still able to receive implants.[36]

A case report used DFDBA and acellular dermal grafts for ARP. An acellular dermal graft is an allograft harvested surgically and with all cellular material and epidermal layer removed. The authors found the height of tissue to be acceptable for implant placement and suggested this technique be used where primary closure couldn’t be achieved.[37]

In another study placed a commercially available bioabsorbable sponge of polylactide-polyglycolide in 36 patients. The teeth were surgically extracted, sockets debrided, the sponge inserted and flaps replaced with no primary closure. Six months later all sites were reassessed and implants placed. There were 26 test sockets and 13 controls. All test sockets healed with less bone resorption than the controls especially in the mid-buccal region. The authors suggested that the sponge served as a support to prevent the collapse of the surrounding soft tissue into the socket during the healing process.[38]

The third ITI consensus report showed that immediate implants are a very successful form of therapy.[32] However, it has been reported that implants do not ‘‘preserve’’ the ridge, a study demonstrated that immediate implant placement in a dog model failed to prevent resorption of the socket walls, especially buccally. They suggested that this may be due in part to the early disappearance of the bundle bone and also disruption of the blood supply buccally due to elevation of a flap. Bundle bone, in the presence of a tooth, occupies a larger fraction of the marginal portion of the bone wall in the buccal than lingual and has a large number of fibres from the periodontal ligament inserting.[39]

It seems that when a tooth is removed bundle bone is resorbed rather than replaced. If one thinks in terms of solely being able to place an implant then this may not matter at all as long as there is enough bone initially, but this may cause problems later especially in aesthetic areas if there is buccal tissue loss.

COMPLICATIONS

It needs to be mentioned that any surgical procedure may have complications. These commonly are postoperative pain and swelling, and occasionally infection. Any surgery on the gingival tissues will cause some recession. It is well known that in guided tissue regeneration (GTR) procedures up to 70 per cent of non-resorbable membranes may become exposed to the oral environment, severely reducing the amount of new tissue formed. In addition, Girard et al. reported a case of a foreign body granuloma following placement of a graft into an extraction socket with pain and sensation disturbance.[40] It should be noted that the site was already compromised by previous infection and may serve as a reminder to debride sockets fully or not to undertake preservation in the presence of infection.

INDICATIONS FOR RIDGE PRESERVATION

ARP should be considered if an implant is to be placed more than six to eight weeks after tooth extraction. If an implant is to be placed at the time of extraction or within six to eight weeks following extraction, there appears to be little benefit in carrying out ARP procedures at the time of extraction. Even when an implant might not be planned in the near future, ARP should be considered in strategically important sites to retain the possibility of an implant option for the patient in the future.[26] ARP should also be considered for aesthetic reasons at pontic sites in conventional fixed prosthodontics. Specific indications for ARP include the following:[26]

(1) Sites where the buccal plate is less than 1.5–2 mm thick (virtually always in the anterior and aesthetic zone) and sites where there has been damage or loss of one or more of the socket walls. These sites may lose a clinically significant amount of the buccal plate upon healing and are more likely to present a challenge for successful implant therapy;

(2) Sites where maintaining bone volume is crucial to minimize the risk of involving anatomical structures, such as the posterior maxilla or mandible, where the maxillary sinus or inferior alveolar nerve may present as a complication if further bone is lost;
(3) A patient with high aesthetic demands, such as a high lip line or a thin biotype, which is prone to more recession;

(4) In patients where many teeth are to be extracted and preservation of the bone is important of further restoration. It should be noted that it is difficult to predict how sites will heal. Some sockets will heal without much resorption, whereas others will lose a lot of hard and soft tissue. If the patient has had a number of previous extractions then the loss of supporting ridge at these sites might provide an indication of what will happen. It appears that if there is any doubt about hard and soft tissue loss then one should try to preserve the ridge.

CONTRAINDICATIONS TO RIDGE PRESERVATION

Acute infection, where unassisted socket healing is likely to result in good ridge morphology, when maintaining bone volume is not critical and where surgery is contraindicated by medical issues. The patient must consent to the procedure also, which will involve explaining the source of all materials. There might be religious and ethical issues with some of the materials (i.e., vegetarians and vegans with animal products).[26]

CLINICAL IMPLICATIONS FOR PRACTICE

- Socket preservation procedures seem to be effective in limiting horizontal and vertical ridge alterations following tooth extraction.
- The use of barrier membranes alone might improve normal wound healing in extraction sites.
- Flap elevation and soft tissue primary closure seem to have little effect on horizontal and vertical bone loss at extraction sites.
- Evaluation of the cost/benefit ratio should be taken into greater account from the biologic and economic points of view. In fact, untreated extraction sites usually show normal healing. Furthermore the various biomaterials suggested probably have a wide range of costs.[41]

RUBBER DAM

Advantages

- Good manageability.
- The close adaptation to the root surface interproximal concavities.
- The possibility of simultaneously treating multiple adjacent periodontal defects.

- Ability to seal off the coagulum from bacterial contamination.
- The negligible economic cost.[42]
- Better handling properties.[43]
- The main advantages of rubber dam (RD) membranes seem to be associated with their abilities to intimately adapt coronal to complex root topographies and to seal off the surgical regenerative sites from oral fluids and bacteria in addition, several adjacent defect environments can be easily treated with just one membrane.[44]
- RD can be placed at more coronal level respect to PTFE membrane because of its tight fitting and adherence to the root circumference.[45]

The elastic tension of the RD provided an effective support for the gingival flap and a seal the roots, maintaining a good seclusion of the space for regeneration from the oral cavity.[46] RD as barrier membranes, are generally sterilized by chemical agents, 2.0% glutaraldehyde solution, and kept in 0.2% chlorhexidine solution. The residual of these agents inhibited the growth and attachment of human gingival fibroblasts. The alternative methods for RD sterilization are either gamma radiation or steaming in an autoclave. Gamma radiation did not affect the cell growth and attachment. Steaming in an autoclave, on the other hand is more routinely used as a common method of sterilization. Gamma radiation was used at 25 kGy and the autoclave sterilization was performed at 121°C, 15 psi for 12 min. The chemical sterilization was performed by immersing RD in 2.0% chlorhexidine solution for 24 h, rinsed and kept in 0.2% chlorhexidine solution for atleast 12 h, and then washed with normal saline.[42] Chemically sterilized RD was toxic to cultured human gingival fibroblasts. Autoclaved RD have no deleterious effect on human gingival fibroblasts. Change in some areas of autoclaved RD such as melted areas, small pores and folds might affect the attachment of the deposits on the barrier membrane surfaces. Some physical property changes represent a deterioration of the autoclaved RD such as the tensile strength, tear strength and elongation at break were also significantly altered when compared with the non-autoclaved RD.[42]

The dental RD was positioned as the sama way as which teeth are isolated for restorative procedures. One hole was punched in the dam for each tooth adjacent to the defect utilizing a RD punch. The dam was then stretched over the teeth, to place it as a poncho over the denuded bone. Four weeks after placement, RD was removed after elevation of a partial thickness flap. No allergic reaction to the material, neither any swelling nor suppuration. All membranes became exposed interproximally by the second weekly visit.

The lack of connective tissue integration into the membrane because of the smooth and non-porous nature of the RD resulted in inadequate stabilization of the membrane and consequently made maintenance more demanding as it resulted in not only earlier exposure of the membrane but also enhanced epithelium migration down the inner aspect of the mucogingival flap compared with the other materials.

Bacterial aggregation on the membranes has been mentioned as a major disadvantage. But this problem may not be seen in RD as little bacterial aggregation can occur, due to its non porous surface. Ability to treat multiple adjacent intrabony defects simultaneously is a distinct advantage over other materials. And also it has an excellent bio-compatibility.[43]

One of the problems encountered with RD is its lack of rigidity. If the same material can be reinforced to make it a little more rigid, possible collapse of the membrane into the defects could be prevented. Further, if the cervical portion is made tissue adherent this might result in better tissue adaptation and also might prevent recession.[43]

Sterilized dam was trimmed to cover the defect, slightly overlapping the edges of the defect. For osseous defects three holes were punched in to the dam with the help of sterile RD punch. The barrier membrane was extended to include at least one tooth on either side of the defect. Removal of membrane was performed easily with minimal trauma to the newly forming tissues.

RD as a barrier membrane fulfils majority of the biological principles of GTR such as biocompatibility, manageability, space-making ability and impermeability to bacteria. The exposure of membrane occurs immediately after surgery is a complication that can significantly influence the outcome of the regenerative therapy. To control this undesirable side effect, the exposed site is subjected to a closer maintenance protocol involving the use of local antimicrobials/antiseptics. Chlorhexidine gels are one of the most commonly used agents in this situation. Drawback is membrane exposure, as gingival connective tissue fails to penetrate the RD membrane.[43]

When the RD material invariably became exposed interproximally, there is no swelling, suppuration at the treatment sites, one possible explanation may be that the RD promotes drainage, while its non porous surface may reduce plaque adherence and therefore may be easier to cleanse during the course of membrane maintenance.

Easily adapt to several teeth in one application is a unique advantage. A related advantage is the elimination of the need for multiple sutures and suture knots, so it decreases the time required to perform the surgical procedure. RD has the ability to retain its position, allowing a tenting effect that creates and maintains an enhanced interproximal “regenerative space” for GTR.

Tissue integration

Connective tissue integration into the membrane is an important requirement for an occlusive barrier utilized in GTR procedures. The lack of this characteristic was the main observable disadvantage of the RD membrane. The same nonporous surface that minimized microbial colonization made tissue integration impossible. This consequently made maintenance more demanding, because it resulted in somewhat earlier exposure of the membrane and enhanced epithelial migration down the inner aspect of the mucogingival flap compared with other materials.

Because of the resulting lack of flap stabilization, recession was a consistent finding. While this recession helps to reduce eventual probing depth. During membrane removal de-epithelialization the inner surface of the flap is required at the membrane removal.[44]

ASSESSMENT METHODS

Radiography is an alternative, non-invasive technique for determining the AB quantity as well as the quality. During surgical procedure, it is essential to know the location of vital anatomical structures such as the inferior alveolar nerve and the extension of e.g. the maxillary sinus. And also it is used to identify possible pathological conditions. So radiographic examination is an important part of the implant treatment planning**.**

COMPUTED TOMOGRAPHY:

Like conventional tomography, this method produces cross-sectional cuts of the jawbone. The technique was introduced by Hounsfield (1973) in the 1970s, and it was based on cross-sectional imaging in the axial plane. It produces direct coronal and sagittal images similar to film tomograms. Instead, computer software was developed, and used for transforming the data of these axial slices into panoramic images and multiplanar cross-sectional images. This transformation is also known as reformatting or reconstruction. In the late 1980s, commercial programs were developed for application of CT.

The advantages of CT include: multiplanar views, high contrast, image layer free of blurring, uniform magnification (”real-size” imaging is possible), availability of image analysis by computer, and 3-dimensional reconstruction. In addition, many implant recipient sites can be evaluated in one exposure. However, CT is also associated with limited accessibility, high expenses, and high radiation doses. Another problem is that presence of metallic restorative materials can cause streak artefacts. For that reason, CT may be more appropriate in the treatment planning of fully edentulous patients.

CT visualize what the conventional radiographs never showed: the thickness and level of the AB. Previously to the introduction of CT, the visualization of labial and lingual bone plates was not possible in the conventional radiographs due to superimposition.

Analyzing an axial section of the maxilla at the level of the middle third of the roots, labial/buccal bone plate is very thin both in the anterior and posterior regions. The permanent canines, and the mesiobuccal root of the first molars, present a buccal bone plate even thinner compared to the other maxillary teeth. The maxillary lingual bone plate is thicker than the buccal bone plate.

In mandible, the buccal bone plate also is very thin, except in the second and third permanent molars which are covered for a very thick buccal plate. Equally to the maxilla, the lingual bone plate of mandibular teeth is thicker compared to the buccal bone plate, except in the lower incisor regions which show a very thin bone plate both in the labial and lingual aspects. In mandible the thickness of the alveolar ridge remarkably decreases from the posterior to anterior region.[47]

STUDIES

Eskow AJ et al (2014) compared histologic and clinical healing following tooth extraction and ARP with either cortical or cancellous freeze-dried bone allograft (FDBA) in non-molar extraction sockets. Forty patients requiring implant placement were enrolled, with 20 patients randomly assigned to each group (cortical versus cancellous FDBA). All of the allograft materials were obtained from the same donor to control for variability between donors and processing. Patients returned after 17 to 21 weeks (average: 18.2 weeks), and a 2-mm-diameter core biopsy was obtained before implant placement. Histomorphometric analysis was performed to determine percentage of new bone formation, residual graft material, and non-mineralized connective tissue /other material. Clinical measurements of ridge dimensions were taken at the time of tooth extraction and again at implant placement. There was no significant difference in new bone formation between the cortical and cancellous FDBA groups ($P = 0.857$). A significantly greater percentage of residual graft material was detected in the cortical FDBA group compared with the cancellous FDBA group ($P = 0.019$). A significantly greater percentage of non-mineralized connective tissue/other material was found in the cancellous FDBA group compared with the cortical FDBA group ($P = 0.040$). The only significant clinical difference between groups was a greater loss of lingual ridge height in the cancellous group. This is the first reported study to compare the histologic changes following tooth extraction with ARP in humans using cortical versus cancellous FDBA. There were no differences in the percentage of new bone formation between the groups.[48]

*Nagarale G et a*l (2012) evaluated the efficacy the dental RD as a barrier membrane in the treatment of infra bony defects. Fifteen patients who were diagnosed to have mild to moderate periodontitis having at least one angular defect were taken up for the study. After the routine basic periodontal therapy these sites were treated with RD as a barrier membrane in accordance with the principle of guided tissue regeneration. All membranes were removed four weeks after membrane placement. The results showed a significant improvement in all clinical parameters including reduction in periodontal probing depth and gain in clinical attachment level after 6 to 9 months post-operatively. Radiographic measurements also showed a mean reduction in osseous defect depth of 0.94 mm. The sites however, showed an increase in gingival recession amounting to a mean of 1.46 mm. It can be concluded that dental RD is a barrier membrane with great potential in treatment of periodontal osseous defects provided the limitations brought to light in the study are addressed in the future.[43]

Deporter DA (2014) reported with a patient required for removal of teeth 17 and 16 as a result of advanced bone loss and an endodontic–periodontic lesion at tooth 16. The patient began taking metronidazole, 250 mg every 8 hours, 24 hours before surgery. Both teeth were extracted, and, after thorough debridement using currets and saline irrigation, their sockets were packed with bovine porous bone mineral covered by a dense PTFE barrier secured with sutures. The barrier was removed after 1 month. After 6 months healing, two dental implants were placed using submerged technique. Four months later, the implants were uncovered and restored with cement-retained crowns. The patient was contacted 1 year after restoration for reevaluation, at which time both implants showed bone loss. At site 17, a large subgingival cement deposit was seen in radiographs. At tooth 16, bone loss mirrored the original endodontic–periodontic lesion, suggesting that it had not been eradicated. Amoxicillin, 500 mg every 8 hours, was prescribed beginning 24 hours before surgery. The cement on implant 17 was removed, and the associated defect was debrided. Implant #3 was explanted, and its socket was debrided and regrafted using bovine porous bone mineral covered with calcium sulfate paste and then a dense PTFE barrier. The barrier was removed at 1 month, and the sites were allowed to heal for 7 months before replacing implant 16. The replacement crown for implant 16 was screw retained, and both implants appeared healthy 1 year later.

Extraction site preservation grafting with xenograft and a barrier is an accepted treatment option but may on occasion result in complications, including failure of dental implants.[49]

After tooth extraction, the AB undergoes a remodeling process, which leads to horizontal and vertical bone loss. These resorption processes complicate dental rehabilitation, particularly in connection with implants. Various methods of guided bone regeneration (GBR) have been described to retain the original dimension of the bone after extraction. Most procedures use filler materials and membranes to support the buccal plate and soft tissue, to stabilize the coagulum and to prevent epithelial ingrowth. It has also been suggested that resorption of the buccal bundle bone can be avoided by leaving a buccal root segment (socket shield technique) in place, because the biological integrity of the buccal periodontium (bundle bone) remains untouched. This method has also been described in connection with immediate implant placement. The present case report describes three consecutive cases in which a modified method was applied as part of a delayed implantation. The latter was carried out after six months, and during re-entry the new bone formation in the AB and the residual ridge was clinically evaluated as proof of principle. It was demonstrated that the bone was clinically preserved with this method. Possibilities and limitations are discussed and directions for future research are disclosed.[50]

Barone A et al (2012) investigated and compared the need for additional augmentation procedures at implant insertion, as well as the success rate and marginal bone loss for implants placed in the grafted sites versus those placed in naturally healed sites Forty patients with single hopeless tooth were randomly allocated to: 1) a test group, receiving extraction and grafting corticocancellous porcine bone; and 2) a control group, receiving extraction without any graft. After 7 months of healing, implants were inserted in each of the sites. The implants were submerged and loaded after 4 months with metal–ceramic rehabilitation. The follow-up included evaluation of implant diameter and length, the need for additional augmentation procedures at implant placement, implant failure, and marginal bone level changes. All patients were followed over a 3-year period. One implant failed in the control group at the second stage of surgery (6 months after placement); one implant failed in the test group after 2 years of loading. The cumulative implant success rate at the 3-year follow-up visit reached 95% for both groups. No statistically significant differences were detected for marginal bone changes between the two groups.[51]

Cioban C et al (2013) investigated the early healing processes developing in the post-extraction sockets preserved with a new-marketed collagen matrix. In both quadrants of the mandible of a mongrel dog, the distal sockets of the second premolars served as experimental sites for ARP. The experimental site 1 was protected with a resorbable membrane and then with the collagen matrix. The experimental site 2 was filled with a xenograft and then covered with the collagen matrix. The samples were harvested after one month of healing. In both experimental sites, the bundle bone lining the inner surface of the alveolus was replaced with trabecular bone containing areas of woven bone. A continuous layer of osteoblasts could be observed on the surface of woven bone areas. Osteoclasts encased within resorptive lacunae lined the outer portions of bone walls for the experimental site 1. The trabecular bone occupied only the apical third of the socket in experimental site 1, but it was obviously more abundant in the experimental site 2, occupying also the central compartment of the socket. Moreover, the trabeculae of the bone occupying the inner area of the alveolus were thicker for the experiment site 2 than for experiment site 1, suggesting an increased osseous deposition in the latter situation. Results suggest that the association collagen matrix plus xenograft may be a valuable method for ARP.[52]

Robert (2012) histologically evaluated and compared the healing of non molar extraction sockets grafted with DFDBA versus FDBA for ARP. The secondary aim of this study was to compare dimensional changes in ridge height and width after grafting with these two materials. Forty patients were randomly divided into two groups of 20. Extraction sockets were filled with either FDBA or DFDBA. To minimize variables associated with the organ donor and with tissue processing, all of the graft material was procured from a single donor; the only difference in the two materials was the percentage mineralization of the final bone graft. A 2-mm-diameter core biopsy was taken from each grafted site 19 weeks after grafting. Histomorphometric analysis was performed to determine percentage of vital bone, residual graft particles, and connective tissue /other non-bone components. There were no significant differences when comparing changes in alveolar ridge dimensions of the two groups. There was no significant difference in percentage connective tissue/other between groups. DFDBA had a significantly greater percentage of vital bone at 38.42% versus FDBA at 24.63%. The DFDBA group also had a significantly lower mean percentage of residual graft particles at 8.88% compared to FDBA at 25.42%. This study provides the first histologic and clinical evidence directly comparing ARP with DFDBA versus FDBA in humans and demonstrates significantly greater new bone formation with DFDBA.[53]

Reviewed of the current ARP literatures well depict the necessity of further esthetic considerations through the corrective procedures of the alveolar ridge upon and post extraction. *Gholami GA* et al (2012) described a new technique with rotational pedicle combined epithelialized and connective tissue graft (RPC graft) adjunct with immediate guided tissue regeneration (GBR) procedure. The main advantages of RPC graft would be: stable primary closure during bone remodeling, saving or crating sufficient vestibular depth, making adequate keratinized gingiva on the buccal surface, and being esthetically pleasant.[54]

Moghaddas H et al (2012) evaluated the efficacy of the palatal connective tissue as a biological membrane for socket preservation with DFDBA. Twelve extraction sites were treated with DFDBA with (case group) and without (control group) using autogenous palatal connective tissue membrane before placement of implants. Alveolar width and height, amount of keratinized tissue, and gingival level were measured at pre-determined points using a surgical stent at two times, the time of socket preservation surgery and 4 months later during implantation. The significance level was set at 0.05. In both groups a decrease in all socket dimensions was found. The average decrease in socket width, height, keratinized tissue, and gingival level in case group was 1.16, 0.72, 3.58, and 1.27 mm, and in control group was 2.08, 0.86, 4.52, and 1.58 mm respectively. Statistical analysis showed that decrease in socket width ($P = 0.012$), keratinized tissue ($P \leq 0.001$), and gingival level ($P = 0.031$) in case group was significantly lower than that of the control group. Results showed no meaningful difference in socket height changes when compared with case and control groups ($P = 0.148$). On Conclusion connective tissue membrane could preserve socket width, amount of keratinized tissue, and the gingival level more effectively than DFDBA alone. [55]

Brownfield LA et al (2012) studied via randomized, controlled clinical trial is to determine whether ARP using an osteoinductive allograft (test) would prevent ridge resorption and promote bone maturation compared to extraction alone (control). Seventeen patients (20 total sites), in need of a non-molar extraction and delayed implant placement were randomly selected to receive either ARP or extraction alone. A cone-beam computed tomography was completed with a radiographic stent in place before extraction and 10 to 12 weeks postoperatively for dimensional and buccal plate analyses. Bone cores were taken for micro-computed tomography (microCT) and histologic analyses. Resorption of the alveolar ridge occurred at all sites with no statistically significant differences found between test and control sites. A significant correlation was found between the initial buccal plate thickness and the loss of vertical ridge height. MicroCT and histologic analyses found a mean new bone volume of 44.9% with microCT and 37.4% with histology in test sites and 39% and 35.5%, respectively, in control sites. The residual graft volume was 2.4% with microCT and 4.5% with histology. Test and control sites lost similar amounts of alveolar ridge, with the loss of bucco-lingual width occurring predominately at the expense of the buccal bone. A thicker buccal plate was associated with less ridge loss in the vertical dimension. The percentage of new bone was not statistically significant between either the test or control sites, using either microCT or histologic analyses.[56]

A case report described a female patient aged 20 years with localised aggressive periodontal disease participated in this clinical report. Infra bony defect in the lower anterior region was selected for surgical treatment. RD was trimmed to cover the defect. Orthodontic treatment was done for the realignment of mal positioned teeth one year after the surgery and patient was followed up for a period of three years after surgery. RD membrane did not result in any untoward side effects. Patient did not show any sign of inflammation or recurrence of probing depth at three year follow up period.[43]

Pourabbas R et al 2012 evaluated the effects of deproteinized bovine bone matrix (DBBM) with and without plasma rich in growth factors (PRGF) in canine extraction socket. Distal roots of second and third upper premolars were extracted bilaterally in six mongrel dogs. Buccolingual (BL) and apico-coronal (AC) dimensions of extraction sockets were measured. The extraction sockets were randomly grafted with DBBM+PRGF or DBBM. The ungrafted extraction sockets were allowed to be filled with clot which served as control. The dogs were sacrificed after 3 months and the extraction sockets were evaluated from clinical and histological viewpoints. There were significant differences in post extraction vertical dimensions of the sockets among the study groups. The mean AC changes were 6.25±2.13 mm, 6.83±1.83 mm, and 3.83±1.63 mm in DBBM, BDDM+PRGF, and control groups, respectively (P=0.034). The mean BL dimension reduction in both DBBM+PRGF and DBBM groups was 2.00±1.09 mm, whereas this amount was 2.66±1.47 mm in the control group (P=0.627). The greatest amount of bone resorption occurred in the control group whereas the PRGF group exhibited the least amount of bone resorption. The control group exhibited a complete bone fill and bone formation rate which was more than that in the experimental groups. The findings of this study indicate that using of DBBM with and without PRGF might successfully maintain socket dimensions.[57]

Pelegrine AA et al (2010) evaluated the potential of an autologous bone marrow graft in preserving the alveolar ridges following tooth extraction. Thirteen patients requiring extractions of 30 upper anterior teeth were enrolled in this study. They were randomized into two groups: seven patients with 15 teeth to be extracted in the test group and six patients with 15 teeth to be extracted in the control group. Hematologists collected 5 ml of bone marrow from the iliac crest of the patients in the test group immediately before the extractions. Following tooth extraction and elevation of a buccal full-thickness flap, titanium screws were positioned throughout the buccal to the lingual plate and were used as reference points for measurement purposes. The sockets were grafted with an autologous bone marrow in the test sites and nothing was grafted in the control sites. After 6 months, the sites were re-opened and bone loss measurements for thickness and height were taken. Additionally, before implant placement, bone cores were harvested and prepared for histologic and histomorphometric evaluation. The test group showed better results ($P<0.05$) in preserving alveolar ridges for thickness, with 1.14 " 0.87mm (median 1) of bone loss, compared with the control group, which had 2.46 " 0.4mm (median 2.5) of bone loss. The height of bone loss on the buccal plate was also greater in the control group than in the test group ($P<0.05$), 1.17 " 0.26mm (median 1) and 0.621 (median 0.5), respectively. In five locations in the control group, expansion or bone grafting complementary procedures were required to install implants while these procedures were not required for any of the locations in the test group. The histomorphometric analysis showed similar amounts of mineralized bone in both the control and the test groups, 42.87 " 11.33% (median 43.75%) and 45.47 " 7.21% (median

45%), respectively These findings suggest that the autologous bone marrow graft can contribute to AB repair after tooth extraction.[58]

A study was done to determine if there is any difference in the amount of new bone formation 3 months after extraction and ARP compared to that after 6 months. Minimally traumatic extraction with ARP using mineralized human bone allograft was performed at 38 single-rooted tooth sites in 33 subjects. Sixteen sites healed for an average of 14 weeks (early healing), whereas 22 sites were allowed to heal for an average of 27 weeks (delayed healing) before harvesting bone core samples. Histomorphometric analysis was performed to determine the percent of new bone formation, residual graft particles, and connective tissue/non-mineralized structures for each site. All specimens showed evidence of new bone formation, with most of the residual graft particles surrounded intimately by woven bone. No statistically significant differences in the amount of newly formed bone or residual graft particles were found between the two groups. Overall, the early healing group demonstrated a mean of 45.8% new bone, 14.6% residual graft material, and 39.6% connective tissue/non-mineralized tissue. The delayed healing group showed mean values of 45%, 13.5%, and 41.3%, respectively. The results of this study suggest that waiting 6 months after tooth extraction and ARP using mineralized bone allograft does not provide a greater amount of new bone formation or less residual bone particles compared to that after only 3 months.[59]

Fotek et al 2009 compared extraction socket healing and alveolar ridge alteration after socket augmentation using bone allograft covered with an acellular dermal matrix (ADM) or PTFE membrane. Twenty non-smoking healthy subjects were selected. Each subject required maxillary premolar, canine, or central incisor tooth extraction. The extraction sites were debrided and grafted with a mineralized bone allograft that was covered with an ADM or PTFE membrane. Postoperative appointments were scheduled at 2, 4, and 8 weeks. After 16 weeks of healing, final measurements were performed, and trephine core biopsieswere obtained for histomorphometric analysis. Implants were placed immediately after biopsy harvesting. Eighteen subjects completed the study. All sites healed without adverse events and allowed for implant placement. PTFE membranes exfoliated prematurely, with an average retention time of 16.6 days, whereas the ADM membranes appeared to be incorporated into the tissues. Buccal plate thickness loss was 0.44 and 0.3 mm, with a vertical loss of 1.1 and 0.25 mm, for ADM and PTFE, respectively. Bone quality assessment indicated D3 to be the most prevalent (61%). Histomorphometric analysis revealed 41.81% versus 47.36% bone, 58.19% versus 52.64% marrow/fibrous tissue, and 13.93% versus 14.73% particulate graft remaining for ADM and PTFE, respectively. No statistical difference was found between the two treatment groups for any of the parameters. All sites evaluated showed minimal ridge alterations, with no statistical difference between the two treatment modalities with respect to bone composition and horizontal and vertical bone loss, indicating that both membranes are suitable for alveolar ridge augmentation.[60]

Hoffman et al (2009) investigated the clinical regeneration of extraction sockets using high-density PTFE membranes without the use of a graft material. A total of 276 extraction sockets were evaluated in 276 subjects (151 males and 125 females; mean age, 50.2 years; age range: 24 to 73 years). After extraction, flaps were elevated and a dPTFE membrane was placed over the extraction site. The flaps were repositioned and sutured into place. Primary closure was not obtained over the membranes. The cemento-enamel junctions of the adjacent teeth were used as reference points. Measurements were taken post extraction and 12 months after surgery in the same areas with the help of a stent and were defined as the distance from the reference points to the bone level. Hard tissue biopsies were taken from 10 representative cases during implant placement 12 months after socket preservation. The bone core samples were submitted for histologic evaluation. A stringent plaque control regimen was enforced in all subjects during the 12- month observation period. A significant regeneration of the volume of sockets could be noted by histologic evaluation, indicating that the newly formed tissue in extraction sites was mainly bone. No influence of gender, smoking, age, or clinical bone level before treatment was found on the percentage of bone gain. The use of dPTFE membranes predictably led to the preservation of soft and ha rd tissue in extraction sites.[61]

The preservation of bone volume immediately after tooth removal might be necessary to optimize the success of implant placement in terms of esthetics and function. The objectives of this randomized clinical trial were two-fold: 1) to compare the bone dimensional changes following tooth extraction with extraction plus ARP using corticocancellous porcine bone and a collagenmembrane; and 2) to analyze and compare histologic and histomorphometric aspects of the extraction-alone sites to the grafted sites. Forty subjects who required tooth extraction and implant placement were enrolled in this study. Using a computer-generated randomization list, the subjects were randomly assigned to the acontrol group (EXT; extraction alone) or to the test group (RP; ridge-preservation procedure with corticocancellous porcine bone and collagen membrane). The following parameters were assessed immediately after extraction and 7 months prior to implant placement: plaque index, gingival index, bleeding on probing, horizontal ridge width, and vertical ridge changes. Abone biopsy was taken from the control and test sites 7 months after the surgical treatment. Histologic and histomorphometric analyses were also performed. A significantly greater horizontal reabsorption was observed at EXT sites (4.3 – 0.8 mm) compared to RP sites (2.5 – 1.2 mm). The ridge height reduction at the buccal side was 3.6 – 1.5 mm for the extraction- alone group, whereas it was 0.7 – 1.4 mm for the ridge-preservation group. Moreover, the vertical change at the lingual sites was 0.4 mm in the ridge-preservation group and 3 mm in the extraction-alone group. Forty biopsies were harvested from the experimental sites (test and control sites). The biopsies harvested from the grafted sites revealed the presence of trabecular bone, which was highly mineralized and well structured. Particles of the grafted material could be identified in all samples. The bone formed in the control sites was also well structured with a minor percentage of mineralized bone. The amount of connective tissue was significantly higher in the extraction-alone group than in the ridge-preservation group. The ridge-preservation approach using porcine bone in combination with collagen membrane significantly limited the resorption of hard tissue ridge after tooth extraction compared to extraction alone. Furthermore, the histologic analysis showed a significantly higher percentage of trabecular bone and total mineralized tissue in ridge-preservation sites compared to extraction-alone sites 7 months after tooth removal.[62]

Fickl S et al (2008) assessed contour changes after socket preservation technique in five beagle dogs; the distal root of the third and fourth mandibular premolars was extracted. The following treatments (Tx) were randomly assigned for the extraction socket. Tx 1: BioOss Collagen. Tx 2: BioOss Collagen and a free soft tissue graft. Tx 3: No treatment. Tx 4: The internal buccal aspect was covered with an experimental collagen membrane, the extraction socket w as filled with BioOss Collagen and the membrane folded on top of the graft. Impressions were obtained at baseline, 2 and 4 months after surgery. Bucco-lingual measurements were performed using digital imaging analysis. All groups displayed contour shrinkage at the buccal aspect. Only the differences between the two test groups (Tx 1, Tx 2) and the control group (Tx 3) were significant at the buccal aspect. No measurements of the Tx 4 group could be performed. Socket preservation techniques, used in the present experiment, were not able to entirely compensate for the alterations after tooth extraction. Yet, incorporation of BioOss Collagen seems to have the potential to limit but not avoid the postoperative contour shrinkage.[63]

Jung RE et al (2013) evaluated the radiographic changes of the alveolar ridge following application of different ARP techniques 6 months after tooth extraction. Four treatment modalities were randomly assigned in 40 patients:β-tricalcium-phosphate-particles with polylactid coating (β-TCP), demineralized bovine bone mineral with 10% collagen covered with a collagen matrix (DBBM-C/CM), DBBM-C covered with an autogenous soft-tissue graft (DBBM-C/PG) and spontaneous healing (control). Cone-beam computed tomography scans were performed after treatment and 6 months later. After 6 months, the vertical changes ranged between 0.6 mm (10.2%) for control and a gain of 0.3 mm (5.6%) for DBBM-C/PG on the lingual side and between 2.0 mm (20.9%) for β-TCP and a gain of 1.2 mm (8.1%) for DBBM-C/PG on the buccal side. The most accentuated ridge width changes were recorded 1 mm below the crest: 3.3 mm (43.3%, C), 6.1 mm (77.5%, β-TCP), 1.2 mm (17.4%, DBBM-C/CM) and 1.4 mm (18.1%, DBBM-C/ PG). At all three levels, DBBM-C with either CM or PG was not significantly differing ($p > 0.05$), while most other differences between the groups reached statistical significance ($p < 0.05$). To conclude the application of DBBM-C, covered with CM or PG, resulted in less vertical and horizontal changes of the alveolar ridge as compared with controls 6 months after extraction.[64]

Araújo MG et al (2005) studied dimensional alterations of the alveolar ridge that occurred following tooth extraction as well as processes of bone modelling and remodelling associated with such change. Twelve mongrel dogs were included in the study. In both quadrants of the mandible incisions were made in the crevice region of the 3rd and 4th premolars. Minute buccal and lingual full thickness flaps were elevated. The four premolars were hemi-sected. The distal roots were removed. The extraction sites were covered with the mobilized gingival tissue. The extractions of the roots and the sacrifice of the dogs were staggered in such a manner that all dogs contributed with sockets representing 1, 2, 4 and 8 weeks of healing. The animals were sacrificed and tissue blocks containing the extraction socket were dissected, decalcified in EDTA, embedded in paraffin and cut in the buccal–lingual plane. The sections were stained in haematoxyline–eosine and examined in the microscope. It was demonstrated that marked dimensional alterations occurred during the first 8 weeks following the extraction of mandibular premolars. Thus, in this interval there was a marked osteoclastic activity resulting in resorption of the crestal region of both the buccal and the lingual bone wall. The reduction of the height of the walls was more pronounced at the buccal than at the lingual aspect of the extraction socket. The height reduction was accompanied by a ‘‘horizontal’’ bone loss that was caused by osteoclasts present in lacunae on the surface of both the buccal and the lingual bone wall. The resorption of the buccal/lingual walls of the extraction site occurred in two overlapping phases. During phase 1, the bundle bone was resorbed and replaced with woven bone. Since the crest of the buccal bone wall was comprised solely of bundle this modelling resulted in substantial vertical reduction of the buccal crest.[13]

Fiorellini (2005) evaluated the efficacy of bone induction for the placement of dental implants by two concentrations of recombinant human bone morphogenetic protein-2 (rhBMP-2) delivered on a absorbable collagen sponge (ACS) compared to placebo (ACS alone) and no treatment in a human buccal wall defect model following tooth extraction. Eighty patients requiring local alveolar ridge augmentation for buccal wall defects (≥50% buccal bone loss of the extraction socket) of the maxillary teeth (bicuspids forward) immediately following tooth extraction were enrolled. Two sequential cohorts of 40 patients each were randomized in a double-masked manner to receive 0.75 mg/ml or 1.50 mg/ml rhBMP-2/ACS, placebo (ACS alone), or no treatment in a 2:1:1 ratio. Efficacy was assessed by evaluating the amount of bone induction, the adequacy of the AB volume to support an endosseous dental implant, and the need for a secondary augmentation. Assessment of the AB indicated that patients treated with 1.50 mg/ml rhBMP-2/ACS had significantly greater bone augmentation compared to controls ($P \leq 0.05$). The adequacy of bone for the placement of a dental implant was approximately twice as great in the rhBMP-2/ACS groups compared to no treatment or placebo. In addition, bone density and histology revealed no differences between newly induced and native bone. The data from this randomized, masked, placebo controlled multicenter clinical study demonstrated that the novel combination of rhBMP-2 and a commonly utilized collagen sponge had a striking effect on de novo osseous formation for the placement of dental implants.[65]

Araújo (2005) studied dimensional alterations of the alveolar ridge that occurred following implant placement in fresh extraction sockets. Five beagle dogs were included in the study. In both quadrants of the mandible, incisions were made in the crevice region of the third and fourth pre-molars. Buccal and minute lingual full-thickness flaps were elevated. The mesial root of the four pre-molars root was filled and the teeth were hemisected. Following flap elevation, the distal roots were removed. In the right jaw quadrants, implants with a sand blasted and acid etched surface were placed in the fresh extraction sockets, while in the left jaws the corresponding sockets were left for spontaneous healing. The mesial roots were retained as surgical control teeth. After 3 months, the animals were examined clinically, sacrificed and tissue blocks containing the implant sites, the adjacent tooth sites (mesial root) and the edentulous socket sites were dissected, prepared for ground sectioning and examined in the microscope. At implant sites, the level of bone-to-implant contact was located 2.6 - 0.4mm (buccal aspect) and 0.2 - 0.5mm (lingual aspect) apical of the SLA level. At the edentulous sites, the mean vertical distance between the marginal termination of the buccal and lingual bone walls was 2.2 - 0.9 mm. At the surgically treated tooth sites, the mean amount of attachment loss was 0.5 - 0.5mm (buccal) and 0.2 - 0.3mm (lingual). Marked dimensional alterations had occurred in the edentulous ridge after 3 months of healing following the extraction of the distal root of mandibular premolars. The placement of an implant in the fresh extraction site obviously failed to prevent the re-modelling that occurred in the walls of the socket. The resulting height of the buccal and lingual walls at 3 months was similar at implants and edentulous sites and vertical bone loss was more pronounced at the buccal than at the lingual aspect of the ridge. It is suggested that the resorption of the socket walls that occurs following tooth removal must be considered in conjunction with implant placement in fresh extraction sockets.[39]

Ydtnaz (1998) investigated the efficacy of root form bioactive glass cones implanted into (a) artificial sockets produced by bone splitting of previous extraction sites and (b) fresh extraction sockets, included conventional extraction sockets sutured without implanting the root form bioactive glass cones as a control group (c), total of 16 patients were treated for whom extractions had been indicated due to severe periodontitis, 6 patients with 7 implant sites having Class II or III alveolar ridge deformities comprised the a group. 5 patients with 10 implant sites comprised the b group. Group c, comprised of 5 patients with 10 extraction sites. Alveolar ridge width and height measurements were obtained using study casts preoperatively, immediately postoperatively, and at 3 and 12 months after operation. In the BS group, while the width of the alveolar ridge increased by 2.8 ± 1.18 mm immediately after ridge augmentation procedure and by 2.4±0.93 mm at I year after operation, the height of the alveolar ridge increased by 1.8±l.99 mm and 1.4±1.74 mm respectively ($p<0.05$). In the a group, the differences between preoperative original ridge height and width and postoperative measurements were not statistically significant, which demonstrated the efficiency of this method in preserving the alveolar ridge. In group c, while alveolar ridge width after 12 months had not significantly changed, alveolar ridge height decreased significantly. After 12 months, no dehiscences were detected and the differences in height between the groups remained significant. The results of this study indicate that this procedure is efficient in reconstructing alveolar ridges deformed as a result of extraction, particularly relevant in relation to preparation for subsequent restorative treatment.[66]

Lekovic (1998) evaluated the clinical effectiveness of a bioabsorbable membrane made of glycolide and lactide polymers in preserving alveolar ridges following tooth extraction using a surgical technique based on the principles of guided bone regeneration. Sixteen patients requiring extractions of 2 anterior teeth or bicuspids participated in the study (split-mouth design). Following elevation of buccal and lingual full-thickness flaps and extraction of teeth, experimental sites were covered with bioabsorbable membranes; control sites did not receive any membrane. Titanium pins served as fixed reference points for measurements. Flaps were advanced in order to achieve primary closure of the surgical wound. No membrane became exposed in the course of healing. Reentry surgeries were performed at 6 months. Results showed that experimental sites presented with significantly less loss of AB height, more internal socket bone fill, and less horizontal résorption of the AB ridge. This study suggests that treatment of extraction sockets with membranes made of glycolide and lactide polymers is valuable in preserving AB in extraction sockets and preventing alveolar ridge defects.[5]

Lekovic (1997) included ten patients who required two or more anterior teeth extractions were utilized in this study. Extraction procedures were carried out with a full thickness surgical flap approach. After flap reflection, teeth were removed with a minimum of trauma to the surrounding bone. Following extraction silicone-based impression techniques were used to produce a model of the alveolar process and small metal pins were placed in the alveolus to be used as fixed points to make measurements of ridge dimensions. One socket was covered with an ePTFE barrier membrane (experimental site); the other socket was a conventional control. The soft tissue flaps were then mobilized using periosteal releasing incision and the wound closed with ePTFE mattress sutures. Six months following extraction, patients were treated with flap surgery to expose both extraction sites to remove the ePTFE membranes and to measure ridge dimensions using the pins as fixed points. Clinical and model measurements have shown statistically significant better ridge dimensions at experimental sites than at control ($P < 0.05$). Three patients with exposed membranes had similar dimensional changes as controls. Results from this study suggested that this improved technique offers a predictable alveolar ridge maintenance enhancing the bone quality for dental implant procedures and esthetic restorative dentistry.[4]

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Patients and site selection

Patients were recruited from the Department of Oral and Maxillofacial Surgery of Sri Ramakrishna Dental College and Hospital, Coimbatore. Patients who required extraction of hopeless teeth, located in the aesthetic area (teeth 15–25), and wanted replacement with either an implant or a conventional bridge.

<u>**Inclusion criteria:**</u>

1. Maxillary anterior and premolar teeth indicated for extraction.
2. Non-smokers.

<u>**Exclusion criteria:**</u>

1. Pregnancy & Lactation.
2. Bone diseases or use of the medications that interfered with bone metabolism.
3. History of head & neck radiotherapy, malignancy and chemotherapy.
4. Long term non-steroidal anti-inflammatory therapy.
5. History of systemic diseases that would contraindicate surgical treatment.
6. History of Auto-immune diseases.
7. Presence of acute periodontal or periapical pathology.
8. Presence of dehiscence or fenestration on bone wall of the socket.

The protocol was approved by the ethical committee of Sri Ramakrishna Dental College and Hospital, Coimbatore.

Study design

All the 3 patients (5 extraction sites) were treated in the Department of Periodontics and Oral Implantology, Sri Ramakrishna Dental College and Hospital, who met the inclusion criteria, were consecutively enrolled in the study. Patients were recruited from Jun 2015 to Nov 2015.

All the patients underwent the same socket preservation procedure performed by two different dental surgeons an oral surgeon and a periodontist. The radiographic analysis Computed Tomography (CT) scans was performed at baseline (immediately after the surgical procedure) and 3 months after the surgery. Written informed consent was obtained from each patient before the surgical procedure.

Pre surgical preparation

- One week before surgical procedure, supragingival ultrasonic scaling was done.
- A custom made acrylic template and an extra oral screen with horizontal and vertical lines on the anterior side were prepared to standardize radiographic parameter. (Fig.8 & 9)
- Autoclaving the rubber dam prior to the surgical procedure.

Surgical procedure

A prophylactic antibiotic was prescribed one day before the procedure for each patient (Amoxicillin 500 mg TID for 5 days). Fig.10 and 11 show pre operative clinical and radiographic view of 14 &15. Prior to surgery, the patients were asked to use a mouth rinse contaning 0.2% chlorhexidine for 1 min. Peri-buccal disinfection was performed with 10%

povidone iodine and a sterile field was prepared. A full thickness mucoperiosteal flap was raised with sulcular and two vertical releasing incisions under local anaesthetic infiltration. Then atraumatic extraction was performed using dental luxators by an oral surgeon. (Fig.12)

Extraction sockets were checked for fenestration and dehiscence. Granulation tissue was curetted, and the alveolar socket was rinsed with a saline. The bone graft biomaterial (Osseo graft) which was humidified with a saline (Fig.13) for 10 mins and inserted into the socket without heavy compaction (Fig.14), following which a sterile rubber dam was cut to desired dimension (Fig.15) and adapted over the socket as a non-resorbable membrane (Fig.16). Then the flap was coronally displaced and sutured by simple interrupted suture using 4-0 black silk (Fig.17), following which aluminium foil and periodontal pack were placed (Fig 18 & 19). Suture removal was done 15 days after surgery and if needed, sutures were placed again. Further, the membrane along with suture was removed (Fig.20) 1 month after surgery. The surgical site was routinely reviewed after first month (Fig.21) and third month (Fig.22) post-operatively.

Post operative protocol

Post surgical instructions were given. Analgesics(ibuprofen, 600mg TID) were prescribed for three days and patient were instructed to continue the antibiotics for 5 days. Patient prescribed chlorhexidine gel to apply twice-daily on the surgical site for 10 days; Patients were advised to avoid tooth brushing at the surgical site for 10 days.

Radiographic examinations

Right after the surgical procedure, the patients underwent a baseline CT scan using standardized positioning before any remodelling of the alveolar crest occurred (Fig.23). The patients were asked to wear a custom-made template (Fig.9) that had an extra-oral screen with horizontal(corresponding to the occlusal plane) and vertical lines on the anterior side that also served as references to assist with patient positioning, while taking the CT scan. A second CT scan was performed 3 months later. The irradiation protocol was 45 mAs, 130 Kv with a slide thickness of 0.6 mm.

Methodology for radiographic measurements

The goal was to establish a reproducible rate of horizontal and vertical bone loss after extraction and socket preservation at several levels and sites on the alveolar bone crest. The two CT scans were matched, and sagittal/para-axial plane (red line) that went through the middle of the edentulous alveolar crest was defined (Fig.24-26). Measurements were obtained at the following three sagittal/para-axial sections: (1) in the centre, (2) in the mesial third and (3) in the distal third of the mesio-distal portion of the edentulous crest (Fig.28, 35-40). The horizontal dimensions of the baseline alveolar processes were then determined at the following three levels perpendicular to a reference line determined in the axis of the crest at 2, 5 and 8 mm (Fig 27,29-34). A precise protocol was followed for all measurements. Keeping the baseline measurements on the computer screen, the third month images were kept in the same plane so that the differences could be calculated at each buccal, palatal and occlusal point. After adequate calibration, 27 differences (nine buccal, nine palatal and nine oclussal) were calculated (Fig 41, 42, 43, 44) for each edentulous alveolar socket by two independent examiners, and 15% of the measurements were repeated by each examiner to evaluate the inter and intra-examiner variations.

Armamentarium

Instruments for diagnostic purposes (Fig.5)

Mouth Mirror

Williams probe

Tweezers

Surgical gloves

Face mask

Instruments for extraction purposes (Fig.6)

Dental Luxators

BP blade no: 15 and BP handle

Extraction forceps

Periosteal elevators

Bone curette

Sterile gauze

Instruments for grafting purposes (Fig.7)

Tissue holding forceps

4-0 Black silk suture material

Needle holder

Surgical scissors

Bone Graft carrier

Osseo Graft, Xeno Graft (Demineralised bone material)

Surgical gloves

Stainless steel Scale

Saline

2% Lignocaine Hydrochloride with 1:80,000 adrenaline

Disposable syringes

Sterile Rubber dam

Endodontic file

Instruments for radiographic standardization (Fig.8, 9)

Custom made acrylic template

Extra oral screen

CT machine (Somaton® Emotion; Siemens,Munich, Germany)

DEPARTMENT OF PERIODONTICS AND ORAL IMPLANTALOGY

SRI RAMAKRISHNA DENTAL COLLEGE AND HOSPITAL,COIMBATORE

A METHODOLOGICAL APPROACH TO ASSESS ALVEOLAR RIDGE PRESERVATION PROCEDURE

PROFORMA

.

Name:

Age:

Sex:

Occupation:

Address:

Phone no:

Email:

Inclusion criteria:

1. Maxillary anterior and premolar teeth indicated for extraction.
2. Non-smokers.

Exclusion criteria:

1. Pregnancy & Lactation
2. Bone diseases or the use of the medications that interfered with bone metabolism.
3. History of head & neck radiotherapy, malignancy and chemotherapy.
4. Long term non-steroidal anti-inflammatory therapy.
5. History of systemic diseases that would contraindicate surgical treatment.
6. History of Auto-immune diseases.
7. Presence of acute periodontal or periapical pathology.
8. Presence of dehiscence or fenestration on bone wall of the socket.
9. Tooth extraction done for orthodontic purposes.

Chief complaint:

Reason for tooth extraction:

1. Fracture	:-	
2. Caries	:-	
3. Endodontic failure	:-	
4. Root stump	:-	
5. Others	:-	

Phase I (scaling procedure):-

Antibiotic prophylaxis :-

Alveolar ridge preservation procedure:-

Examination of bone:-

CT scan assessment

Baseline CT scan:-

Second CT scan:-

RESULTS AT BASELINE

Examiner I

Vertical component

Vertical component	Mesial	Medium	Distal
Buccal			
Central			
Palatal			

Horizontal component

Horizontal component	Buccal			Palatal		
	Mesial	Central	Distal	Mesial	Central	Distal
2 mm						
5 mm						
8 mm						

AT BASELINE

Examiner II

Vertical component

Vertical component	Mesial	Medium	Distal
Buccal			
Central			
Palatal			

Horizontal component

Horizontal component	Buccal			Palatal		
	Mesial	Central	Distal	Mesial	Central	Distal
2 mm						
5 mm						
8 mm						

RESULTS AFTER THREE MONTHS

Examiner I

Vertical component

Vertical component	Mesial	Medium	Distal
Buccal			
Central			
Palatal			

Horizontal component

Horizontal component	Buccal			Palatal		
	Mesial	Central	Distal	Mesial	Central	Distal
2 mm						
5 mm						
8 mm						

Examiner II **RESULTS AFTER THREE MONTHS**

Vertical component

Vertical component	Mesial	Medium	Distal
Buccal			
Central			
Palatal			

Horizontal component

Horizontal component	Buccal			Palatal		
	Mesial	Central	Distal	Mesial	Central	Distal
2 mm						
5 mm						
8 mm						

DEPARTMENT OF PERIODONTICS AND ORAL IMPLANTALOGY
SRI RAMAKRISHNA DENTAL COLLEGE AND HOSPITAL,COIMBATORE

Informed Consent & Information for Alveolar Ridge Preservation Surgery

Patient Name____
Date of Birth__________________________

Advanced periodontal disease, tooth fracture, or other types of abscesses may cause severe bone loss around a tooth, requiring extraction of the tooth. When the tooth is extracted, healing occurs by a combination of “shrinkage” of the remaining extraction socket bone and some bone growth from the base of the extraction site. The result is often loss of bone where the tooth used to be and depression in the remaining ridge of bone. This problem can now be avoided. At the time the tooth is extracted, the area is filled with one of resorbable “materials”, and the area is covered with a membrane barrier. The barrier prevents the gum tissue from growing into the extraction area and protects the underlying materials which are forming into bone. The graft materials encourage your own bone to grow into the area and these materials are totally resorbed and eliminated by the body. This treatment will often result in the complete regeneration of the lost bone in the area of the tooth extraction.

Regenerating damaged and lost bone at the time of extraction of the tooth provides the following advantages:

□ The bone between the extracted tooth and the adjacent tooth is preserved or regenerated. The health of the adjacent tooth is thus improved.

□ A ridge deformity does not develop, and the appearance of the ridge is more natural. The aesthetics of the area is preserved or improved.

□ The regenerated bone allows placement of an implant to replace the missing tooth.

If a ridge deformity exists because this procedure was not performed at the time the tooth was extracted, a ridge augmentation procedure can be performed at a later date with beneficial results.

After careful oral examination and study of my dental condition, the Doctor has advised me that I might have deficient alveolar ridge for future implant or bridge placement I understand that this deficient ridge will compromise implant/bridge placement and thus health and longevity of the restoration. I also understand that a deficient ridge can continue to shrink without treatment with implant replacement.

In order to treat this condition, the Doctor has recommended that my treatment include ridge preservation at the time of extraction surgery. Please mark each paragraph after reading. If you have any questions, please ask your Doctor BEFORE marking.

You have the right to be informed about your diagnosis and planned surgery so that you can decide whether to have a procedure or not after knowing the risks and benefits.

1. I have been informed of possible alternate methods of treatment (if any) including: ___________________________

____I understand that these other forms of treatment, or no treatment at all, are choices. The risks of those choices have been presented to me.

2. My Doctor has explained to me that there are certain risks and side effects associated with my proposed treatment and, in this specific instance, they include, but are not limited to:

A. Post-operative discomfort, bruising, and swelling.

B. Prolonged or heavy bleeding that may need treatment.

C. An infection that might affect the new bone graft and need treatment.

D. The graft might not join together with the natural bone. There could be other reasons that the bone graft might be lost.

E. To add to the bone graft, natural pieces of donor bone, or other kinds of synthetic bone are often packed around the bone graft. These pieces might also lose their vitality and be lost. Sometimes this happens over some period of time.

F. Biologic or synthetic membranes or mesh are often used to contain and protect the graft. Some may need a second procedure to remove them; or some may be unexpectedly lost. If so, graft may be adversely affected.

G. Allergic reactions (previously unknown) to any medicines or materials used in treatment.

3. I understand that I need to have the dental implant(s) put in when the graft is ready. If too much time passes, the bone graft may resorb (“melt away”) and there won’t be enough bone into which an implant can be placed.

I have had the opportunity to ask questions and receive answers to and responsive explanations for all questions about my medical condition, contemplated alternative treatment and procedures, and potential complications of the contemplated and alternative treatments and procedures, prior to signing this form.

I have been well informed about the study (Methodological Approach to Assess Alveolar Ridge Preservation Procedure) by the Doctor, and also i am giving my consent for using the findings of surgical procedure & CT scan which can be used for dissertation purpose.

Patient/Guardian Signature____

Date_______________________

Dentist Signature____

Date_______________________

Witness Signature____

Date_______________________

Fig.5. Armamentarium for diagnostic purposes

Fig.6. Armamentarium for extraction purposes

Fig.7. Armamentarium for socket preservation purposes

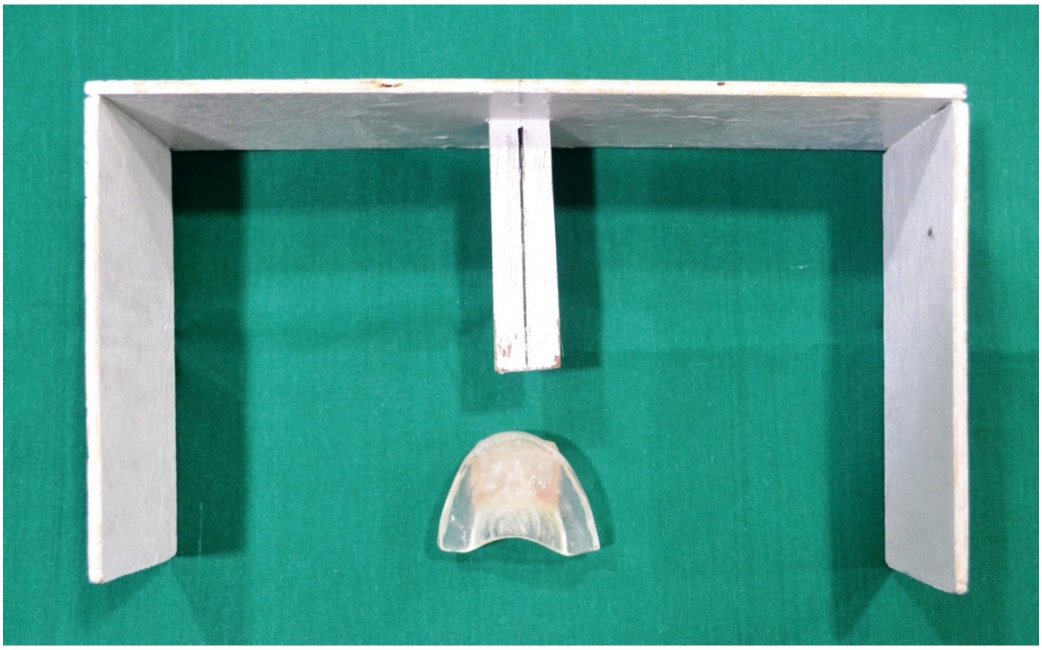


Fig.8. Armamentarium for radiographic standardization

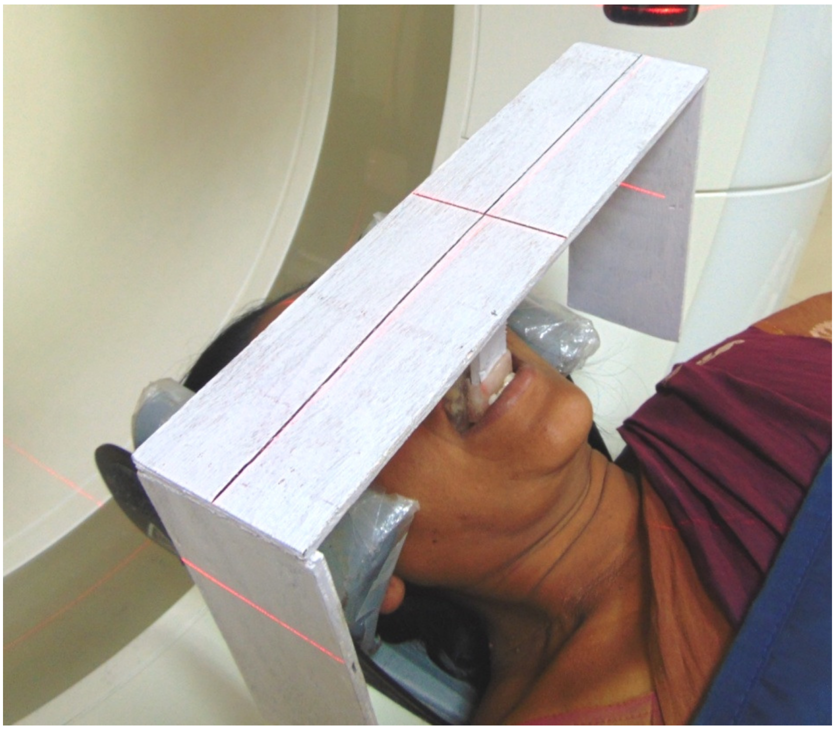


Fig.9. CT Machine while taking CT scan with extra-oral screen and template

Fig.10. Pre operative view of 14 & 15

Fig.11. Pre-operative intra oral periapical radiograph of 14,15

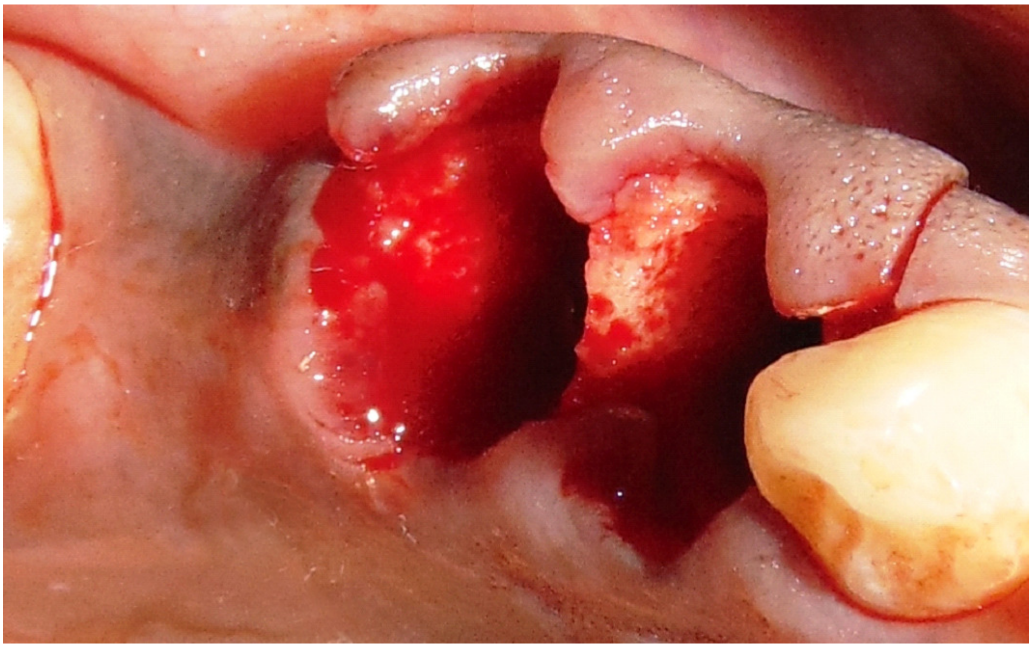


Fig.12. After extraction of 14,15

Fig.13. Bone graft humidified with saline

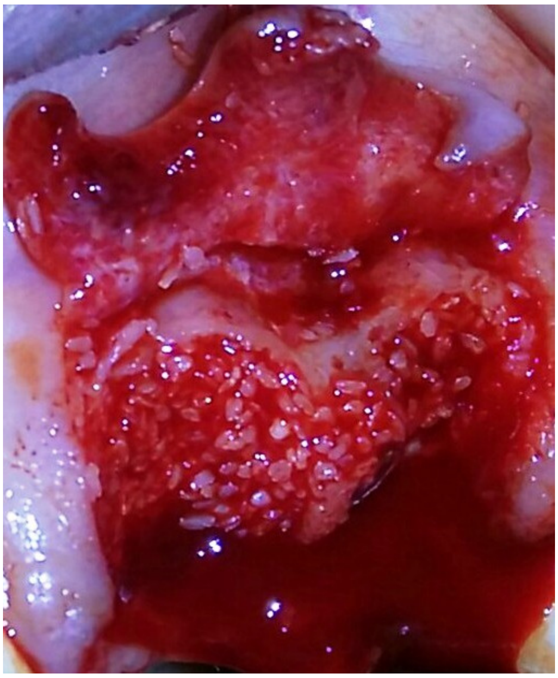


Fig.14. After Grafting in extraction site

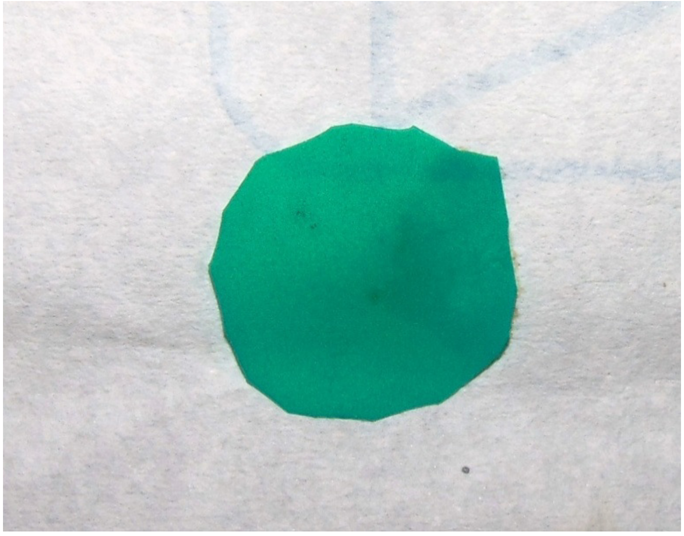


Fig.15. Before placement of rubber dam

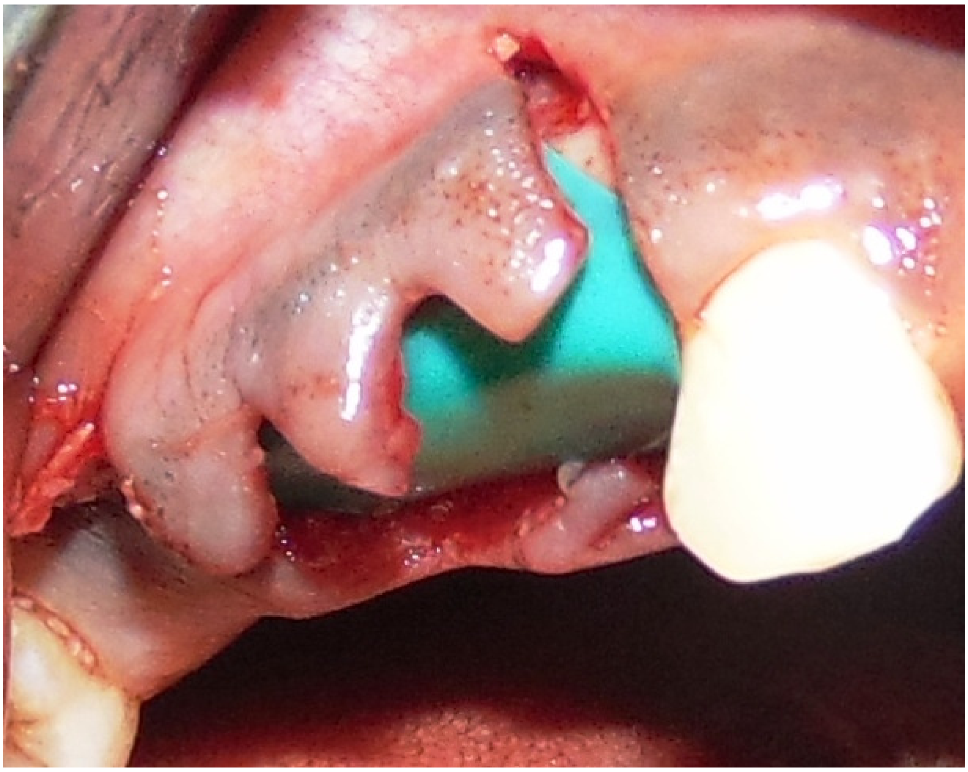


Fig.16. After placement of rubber dam

Fig.17. After suturing

Fig.18. After aluminium foil placement

Fig.19. After placement of periodontal pack

Fig.20. Removed Rubber dam after 1 month

Fig.21. Review after one month

Fig.22. Review after three months

Fig.23. CT scan images

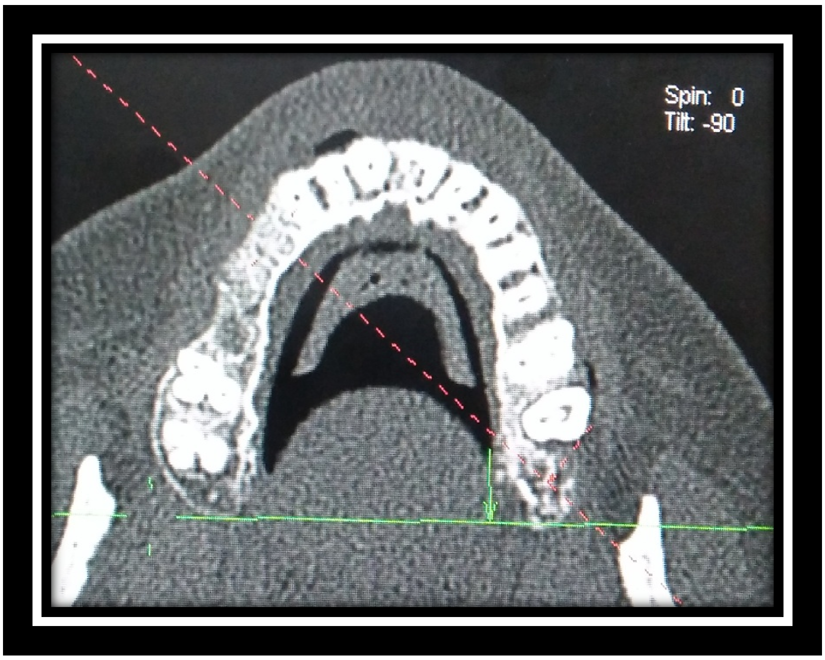


Fig.24. The red line represents the sagittal/ para axial plane located in the middle of the region of interest

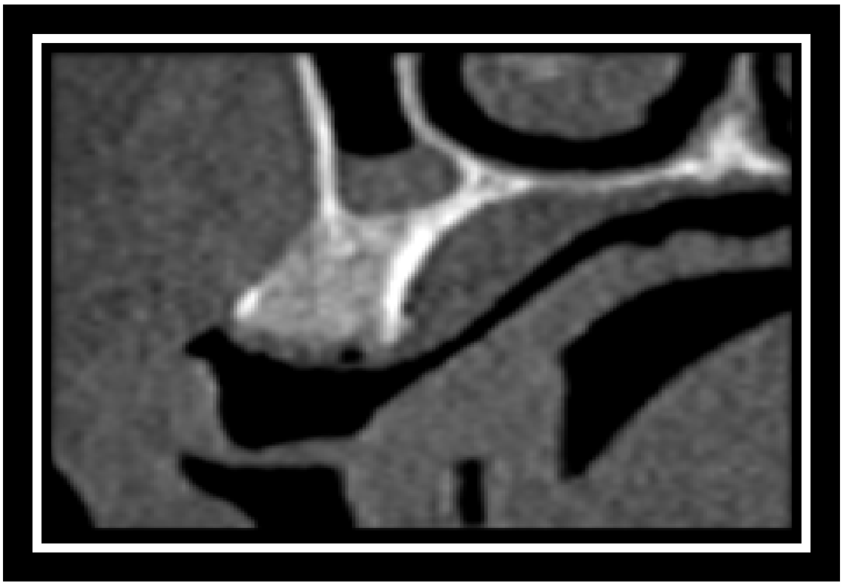


Fig.25. Baseline image - in the centre of the socket

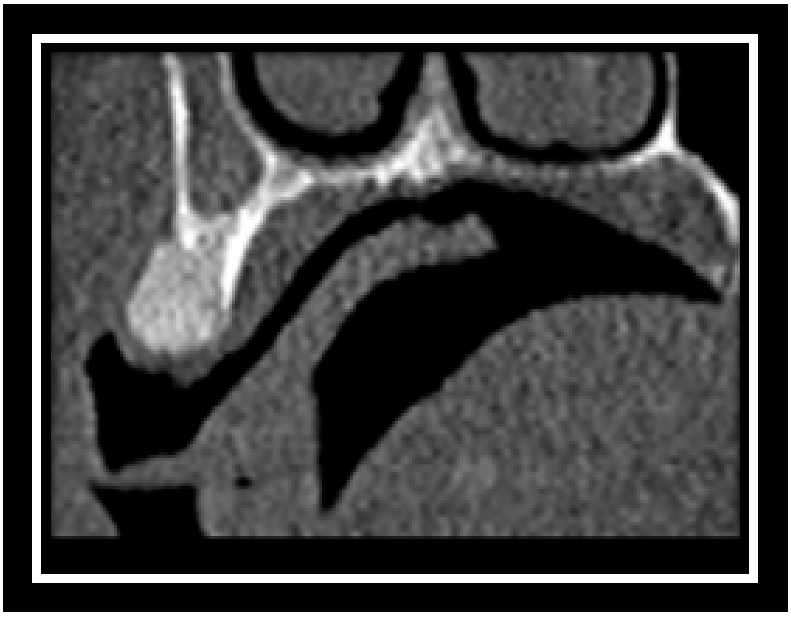


Fig.26. After 3 month image – in the centre of the socket

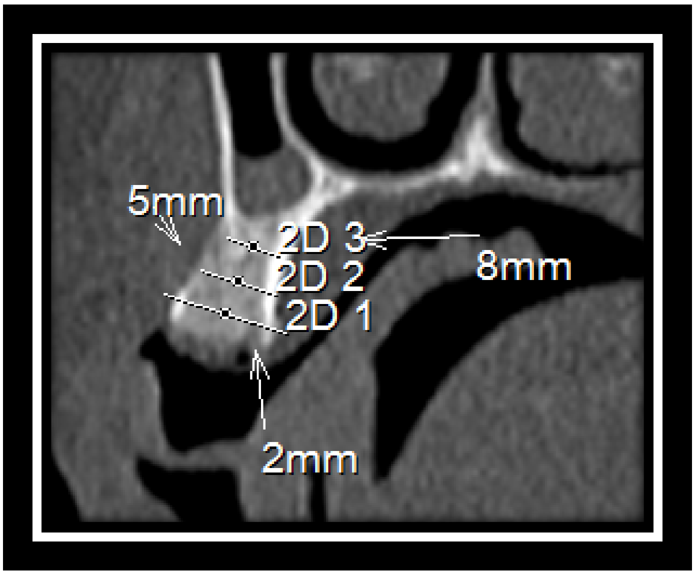


Fig.27. Horizontal sections in the centre image at 2mm, 5mm, 8mm from the alveolar crest

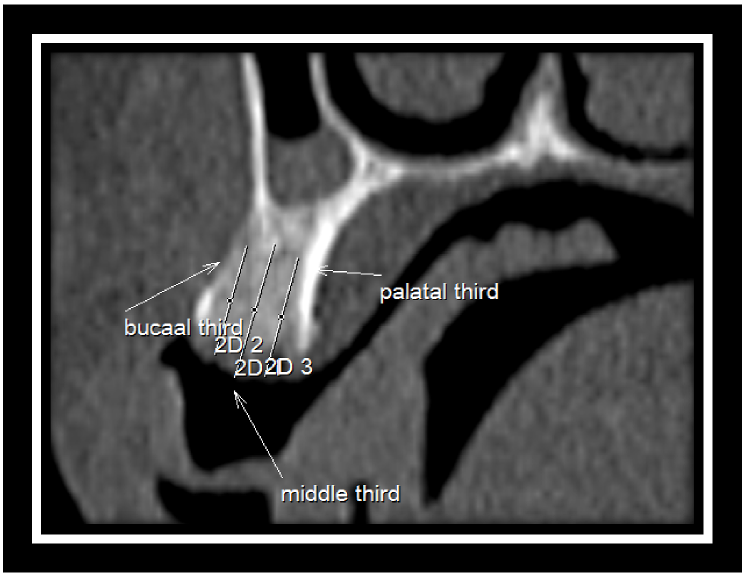


Fig.28. Vertical sections in the centre of the image at buccal third, middle third and palatal third

Fig.29. Horizontal image in 2mm section- Base line

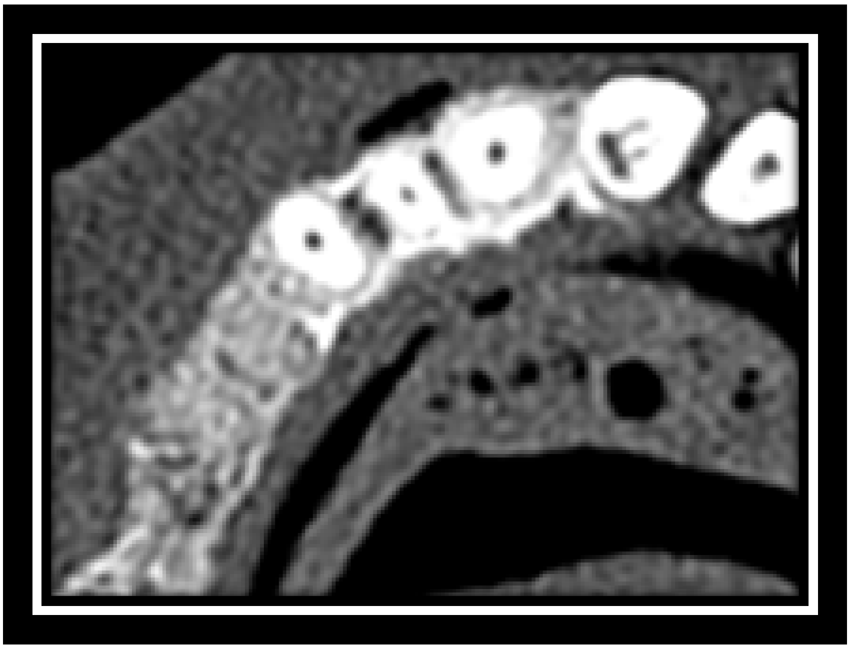


Fig.30. Horizontal image in 2mm section- After 3 months

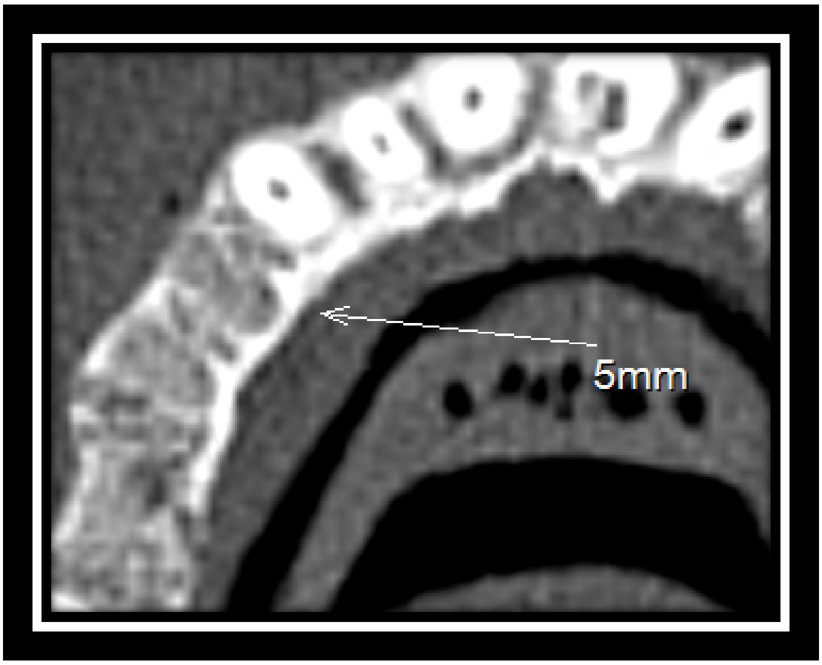


Fig.31. Horizontal image in 5mm section- Base line

Fig.32. Horizontal image in 5mm section- After three months

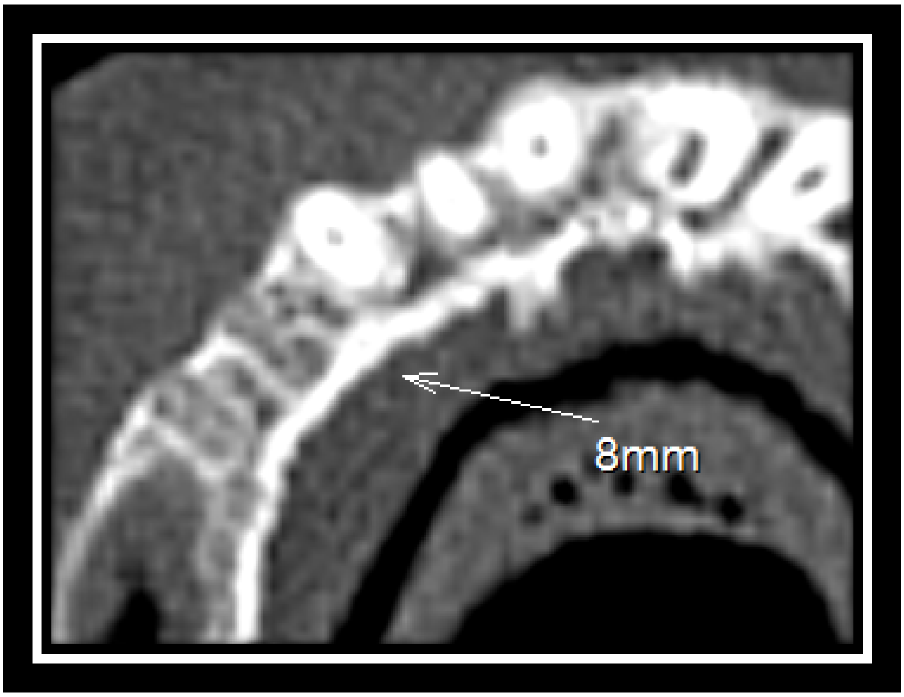


Fig.33. Horizontal image in 8mm section- Base line

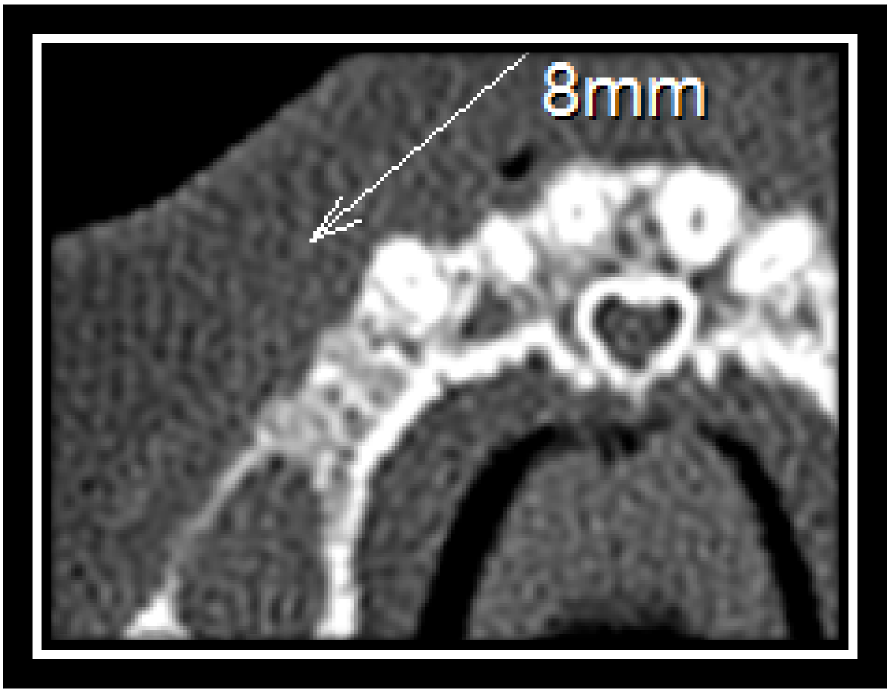


Fig.34. Horizontal image in 8mm section- After 3 months

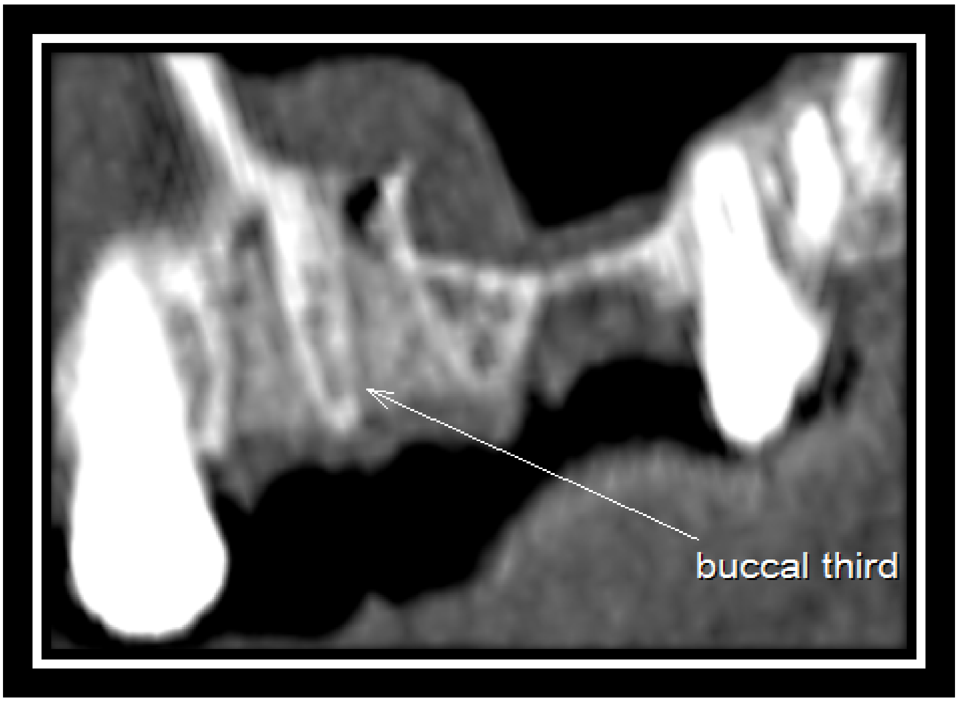


Fig.35. Vertical image in buccal third section- Base line

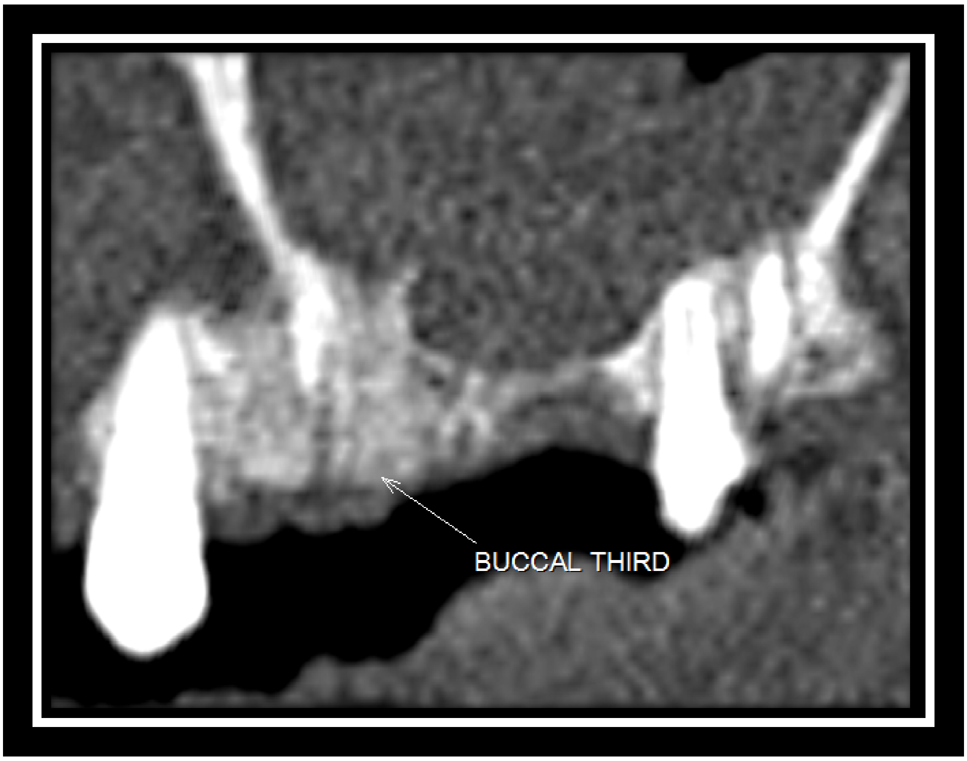


Fig.36. Vertical image in buccal third section- After 3 months

Fig.37. Vertical image in middle third section- Base line

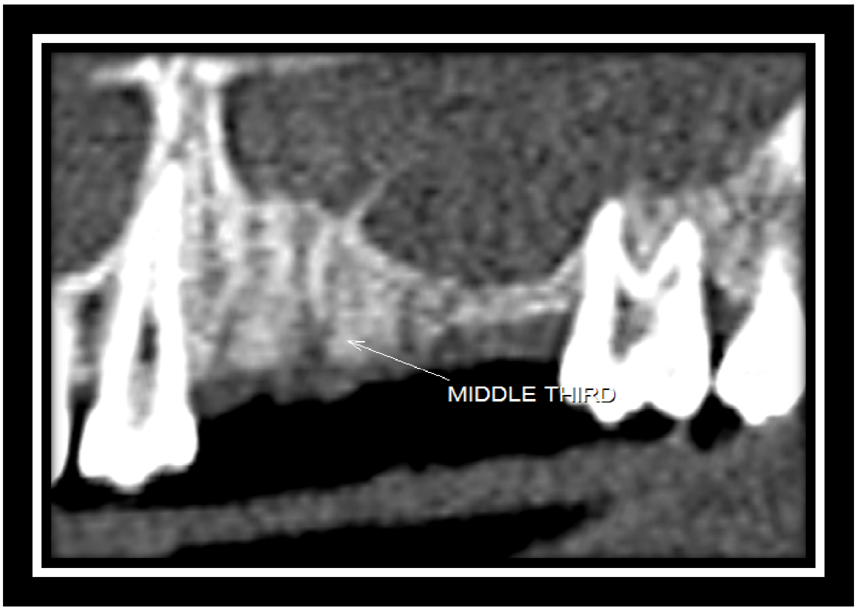


Fig.38. Vertical image in middle third section- After 3 months

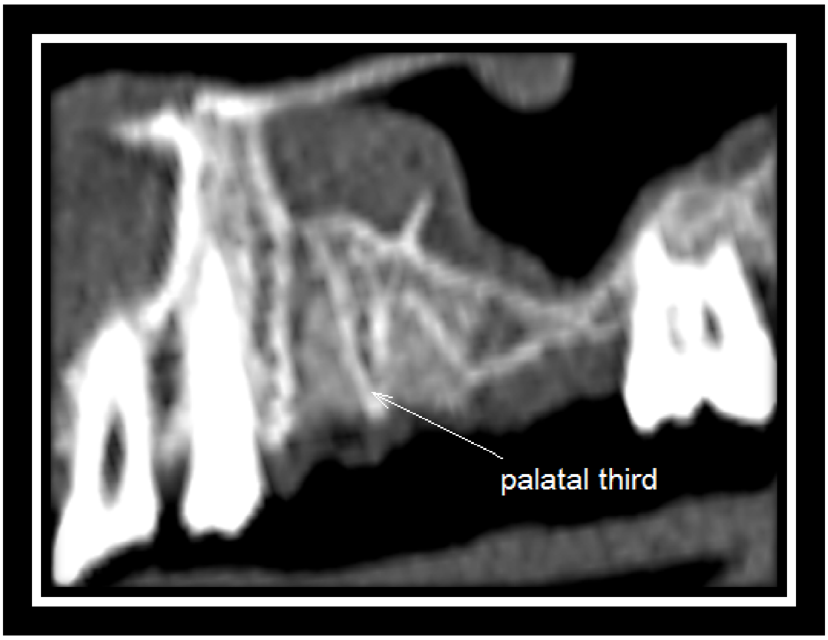


Fig.39. Vertical image in palatal third section- Base line

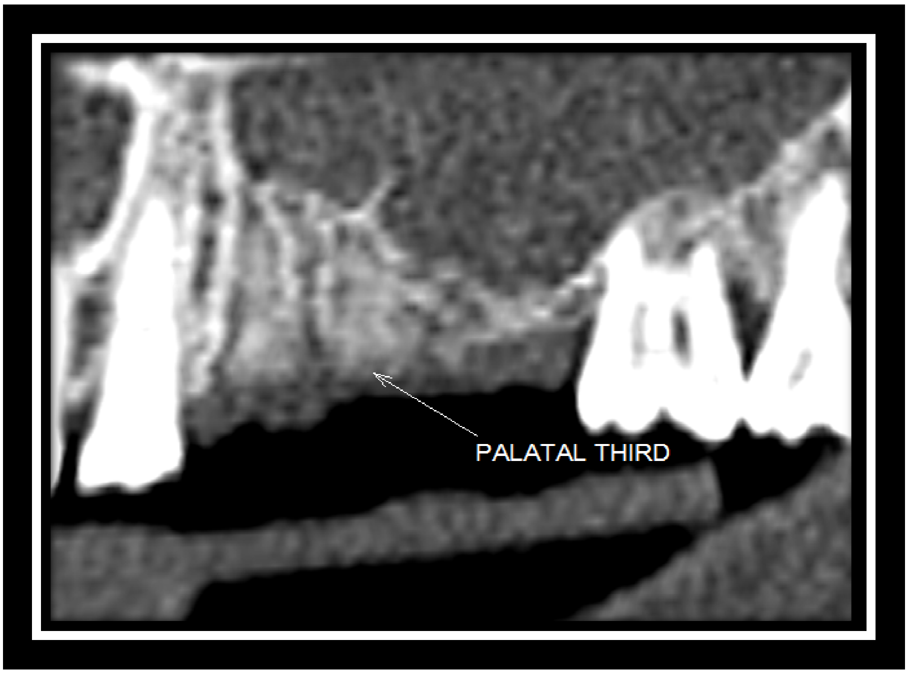


Fig.40. Vertical image in palatal third section- After 3 months

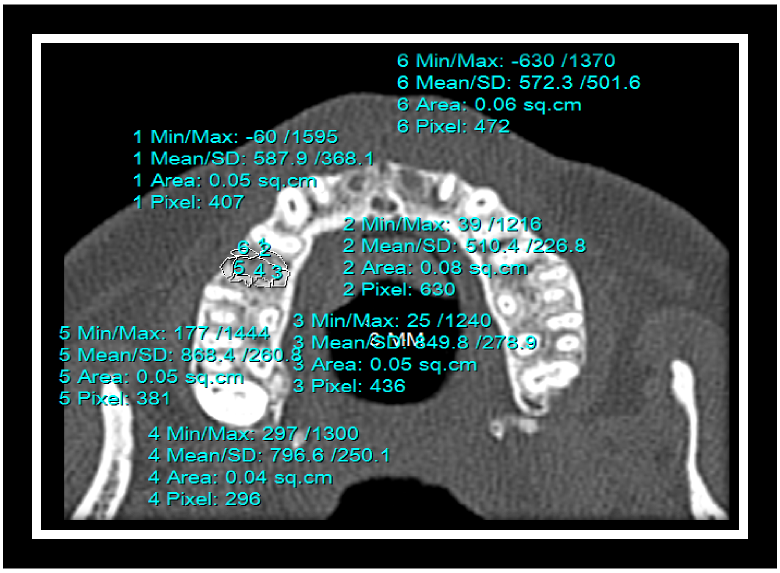


Fig.41. Horizontal section measurements, Buccal –mesial, middle & distal

Palatal- mesial, middle & distal

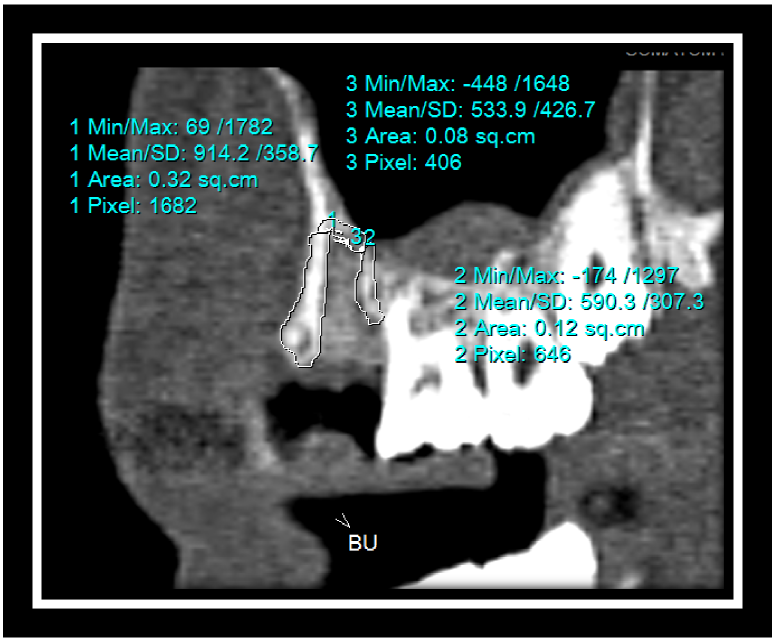


Fig.42. Vertical section measurements- mesial, middle & distal

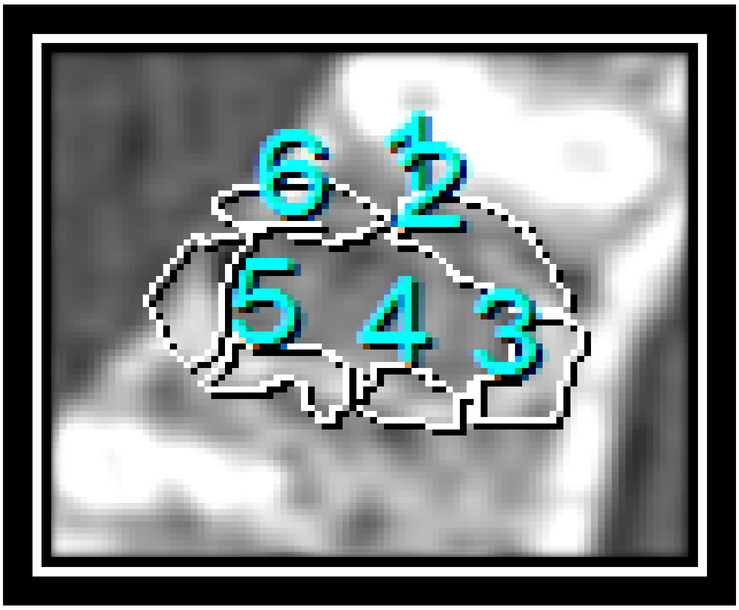


Fig.43. Zoomed view of Fig.41. 1-mesial buccal, 2-mesial palatal, 3-medium palatal, 4-distal palatal, 5- distal buccal, 6-medium buccal.

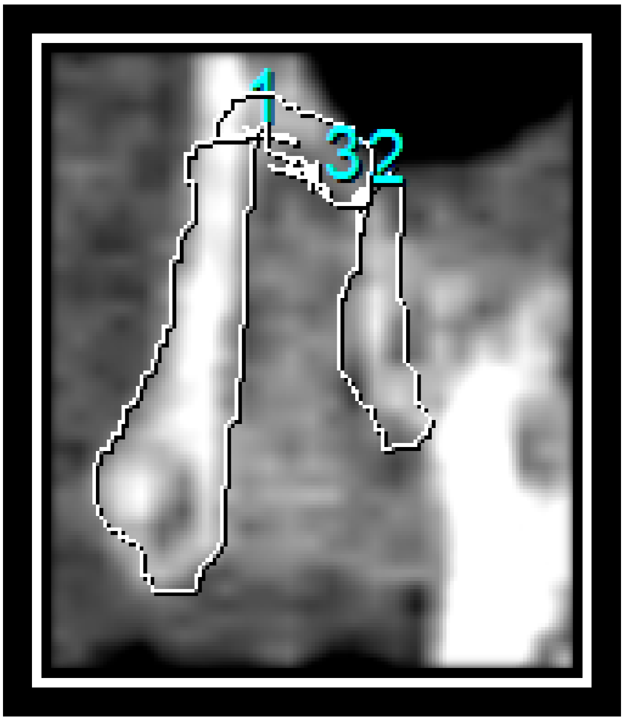


Fig.44. Zoomed view of Fig.42. 1-mesial, 2-distal, 3- medium

STATISTICAL ANALYSES

The results were expressed as means and standard deviations for the continuous variables and as numbers and percentages for the categorical variables. The variations of intra-examiner measurements and inter-examiner measurements were assessed using an intra-class correlation coefficient. Baseline and after three months measurements of each sections were assessed by using a paired student *t*-test. Evaluate the effect of corono-apical level (2 mm, 5 mm, 8 mm) and the effect of mesio-distal level (mesial, central and distal) were by using a general linear mixed model analyses. Vertical and horizontal mean loss of each component was represented graphically. Vertical and horizontal mean bone loss and bone loss in percentage compared with the baseline measurements represented in separate tables. All the results were considered statistically significant if the p value is less than 0.05.

RESULTS

Overall, 5 sites (3 subjects) met the inclusion criteria during the follow- up period and were enrolled in the study. The 3 patients underwent extraction of 5 teeth leading to 5 socket preservation procedures for the following teeth: 2 incisors, and three premolars. The reasons for extraction were dental caries (3 teeth) and cervical abrasion which involving the pulp (2 teeth). All the surgical procedures were successfully carried out as planned without any complications.

Figure 45 represents the sample size of this study. For the student *t* test, the power taken is 80%, so the total number of sample is 5. Table 1 represents the descriptive statistics of samples, with the total number of each variable and its minimum value and maximum value, with mean of total number and its standard deviation. The maximum and minimum values are found to be 9.60 and 0.00 in Medium-After and Buccal-Mesial-After respectively. Similarly, the mean values are maximum (4.89) and minimum (1.2333) in Medium –Before and Buccal-Mesial-After. Table 2 represents the paired samples statistics, along with the pair of before value and after value of each section, and total number of pair, its mean, standard deviation and standard error.

Table 3 represents the paired samples test, before value and after value were combined and take a pair, and their mean, standard deviation and standard error, 95% confidence interval of the difference were showed. The upper and lower bounds of 95% confidence interval of the difference were found to be 1.1515 and 0.1561 respectively at pair 2 and pair 4.

Table 4 represents a paired sample test of before and after value of mesial, medium and distal and it shows a mean, standard deviation, standard error and 95% confidence interval of the difference. The upper and lower bounds of 95% confidence interval of the difference were found to be 2.4647 and 0.6629 respectively at pair 2 and pair 1.

Table 5 represents the vertical mean bone loss with standard deviations of mesial, medium and distal in millimetres, and all values are statistically significant. It shows the buccal mean loss of 1.78±1.157mm, 1.78±2.033mm and 1.22±1.005mm in mesial, medium and distal respectively. Central side mean bone loss of 1.27±1.162mm, 1.07±1.019mm and 1.76±1.338mm in mesial, medium and distal respectively. Palatal side mean bone loss of 1.14±1.029mm, 2.09±1.25mm and 2.39±1.506mm in mesial, medium and distal respectively. Table 6 represents mean bone loss of buccal and palatal side, it shows the maximum (1.52±1.962mm) and minimum (0.24±0.259mm) bone loss in palatal-mesial in 5mm section and buccal-distal in 5mm section respectively. Table 7 represents mean horizontal bone loss, the mean bone loss of 2.093±2.004mm, 1.259±0.624mm, 0.964 ±0.344mm in horizontal sides 2mm, 5mm, 8mm respectively.

Table 8, 9 and 10 represents bone loss in percentage compared with the baseline measurements. Total bone loss in 2mm section is 24.60%, 5mm section is 26.10%, 8mm section is 36.10% and the total horizontal bone loss was 28.93%. Percentages of vertical bone loss in buccal side is 39.90%, central side is 21.60% and palatal side is 27.7%. Total vertical bone loss was 29.73%.

Table 11 represents the inter examiner and intra examiner correlation coefficient. The radiographic measurements showed high reliability, as inter- and intra-examiner observations (0.989 and 0.987 respectively) were concordant for most measurements using an intra-class correlation coefficient.

Figure 46 shows the graphic representations of mean vertical bone loss. Figure 47 and 48 shows the graphic representations of horizontal bone loss.

Inference

1. Total loss of alveolar bone was about 29.3%
2. For the horizontal component, alveolar bone loss was greater in the apical region (36.1% at 8 mm level), moderate in the middle (26.80% at 5mm level) and low in the cervical region (24.60% at 2 mm level).
3. For the vertical component, buccal side alveolar bone loss (39.9%) was greater than the palatal side alveolar bone loss (27.7%), and distal side alveolar bone loss (39.13%) was greater than mesial side alveolar bone loss (25.50%).
4. Among all values, Disto- buccal alveolar bone loss was higher (62.80%).

Suitable test Paired t tests - Means: Difference between two dependent means (matched pairs)

Analysis: A priori: Compute required sample size

Input:	Tail(s)	=	One
	Effect size dz	=	1.36 (It will identify only big differences)
	α err prob	=	0.05 (level of significance)
	Power (1-β err prob)	=	0.8 (80% power of the test)
Output:	Noncentrality parameter δ	=	3.041052
	Critical t	=	2.131847
	Df	=	4
	Total sample size	=	5

Actual power = 0.800288

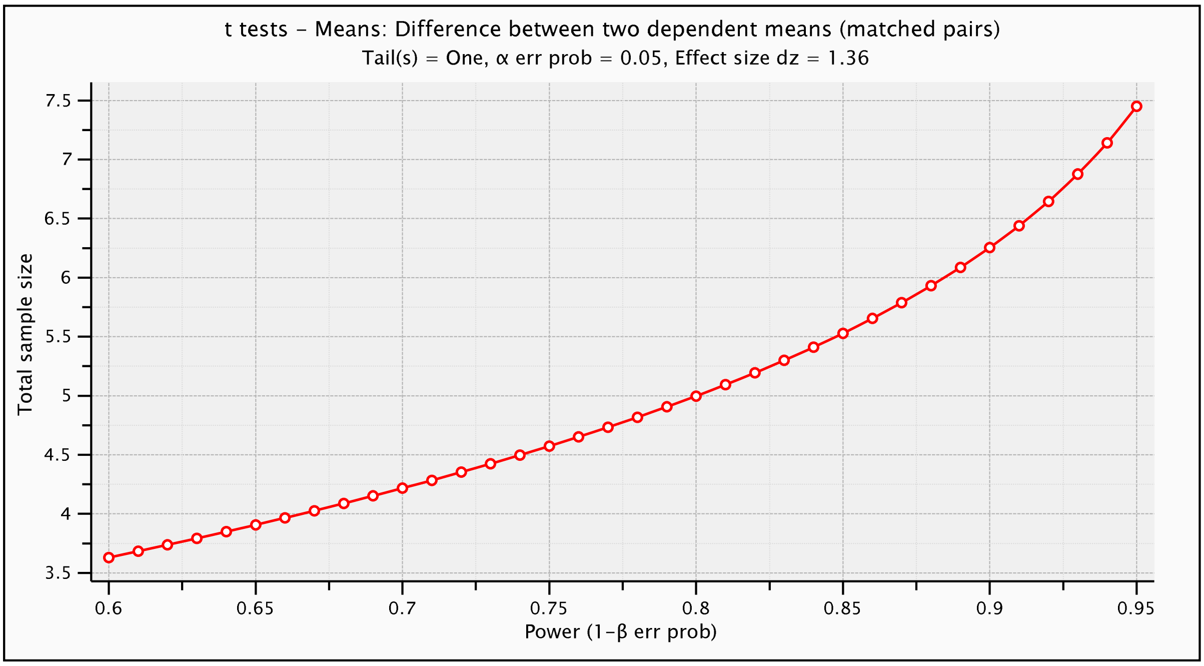


Fig.45. Sample size

TABLE.1. DESCRIPTIVE STATISTICS

SAMPLES	N	Minimum	Maximum	Mean	Std. Deviation
Mesial- After	15	1.60	6.40	3.8067	1.49041
Medium- After	15	2.20	9.60	4.8267	2.04432
Distal- After	15	1.10	4.40	2.3500	.97815
Buccal-Mesial-Before	15	.10	2.90	1.7700	.81712
Buccal-Medium-Before	15	.10	4.60	2.0100	1.65890
Buccal-Distal-Before	15	1.00	3.20	1.9900	.74849
Palatal-Mesial-Before	15	.50	3.60	2.0150	.81459
Palatal-Medium-Before	15	1.10	5.15	2.8800	1.16246
Palatal-Distal-Before	15	.60	3.50	2.1033	.91970
Buccal-Mesial- After	15	.00	2.40	1.2333	.50264
Buccal-Medium- After	15	.00	3.70	1.2600	1.12053
Buccal-Distal- After	15	.40	2.50	1.2867	.57098
Palatal-Mesial- After	15	.15	2.50	1.4400	.48324
Palatal-Medium- After	15	1.00	4.15	1.9000	.80151
Palatal-Distal- After	15	.40	2.80	1.3467	.75463
Mesial-Before	15	1.60	6.50	3.8000	1.41543
Medium-Before	15	2.10	9.40	4.8900	2.42094
Distal-Before	15	1.90	6.60	4.0933	1.52065
Mesial- After	15	.80	4.00	2.6733	.60454
Medium- After	15	1.20	6.70	3.1600	1.38678
Distal- After	15	.80	4.90	2.6333	1.06620
Valid N (listwise)	15				

TABLE.2. PAIRED SAMPLES STATISTICS

Pairs		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Buccal-Mesial-Before	1.7700	15	.81712	.14919
	Buccal-Mesial-After	1.2333	15	.50264	.09177
Pair 2	Buccal-Medium-Before	2.0100	15	1.65890	.15287
	Buccal-Medium- After	1.2600	15	1.12053	.20458
Pair 3	Buccal-Distal-Before	1.9900	15	.74849	.13666
	Buccal-Distal-After	1.2867	15	.57098	.10425
Pair 4	Palatal-Mesial-Before	2.0150	15	.81459	.14872
	Palatal-Mesial-After	1.4400	15	.48324	.08823
Pair 5	Palatal-Medium-Before	2.8800	15	1.16246	.21223
	Palatal-Medium- After	1.9000	15	.80151	.14661
Pair 6	Palatal-Distal-Before	2.1033	15	.91970	.16791
	Palatal-Distal-After	1.3467	15	.75463	.13778

TABLE.3. PAIRED SAMPLES TEST

	Pairs	Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Buccal-Mesial-Before - Buccal-Mesial- After	.5367	.64673	.11808	.2952	.7782	4.545	29	.000
Pair 2	Buccal-Medium-Before - Buccal-Medium- After	.7500	1.07535	.19633	.3485	1.1515	3.820	29	.001
Pair 3	Buccal-Distal-Before - Buccal-Distal- After	.7033	.68957	.12590	.4458	.9608	5.587	29	.000
Pair 4	Palatal-Mesial-Before - Palatal-Mesial- After	.5900	.76038	.13883	.1561	.8739	4.250	29	.000
Pair 5	Palatal-Medium-Before - Palatal-Medium- After	.9800	1.25544	.22921	.5112	1.4488	4.276	29	.000
Pair 6	Palatal-Distal-Before - Palatal-Distal- After	.7567	.87324	.15943	.4156	1.0827	4.746	29	.000

TABLE.4. PAIRED SAMPLES TEST

Pairs		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Mesial-Before - Mesial- After	1.1267	1.24206	.22677	.6629	1.5905	4.968	29	.000
Pair 2	Medium-Before - Medium- After	1.7150	1.96770	.35925	.9953	2.4647	4.816	29	.000
Pair 3	Distal-Before - Distal- After	1.4600	1.33148	.24159	.9628	1.9572	6.006	29	.000
Pair 4	Before - After	1.4387	1.28103	.23388	.9603	1.9170	6.151	29	.000

TABLE.5. VERTICAL LOSS

Vertical components	units	buccal	central	palatal
Mesial	mm (p value)	1.78 ± 1.157 0.002	1.27 ± 1.162 0.007	1.14 ± 1.029 0.007
Medium	mm (p value)	1.78 ± 2.033 0.022	1.07 ± 1.019 0.009	2.09 ± 1.25 0.001
Distal	mm (p value)	1.22 ± 1.005 0.004	1.76 ± 1.338 0.002	2.39 ± 1.506 0.001

TABLE.6. BUCCAL AND PALATAL LOSS

Horizontal		Buccal loses			Palattal loses		
Components	Units	Mesial	Medium	Distal	Mesial	Medium	Distal
2mm	mm (p value)	0.68±0.9 0.041	0.53±0.606 0.022	0.4±0.356 0.006	0.6±1.059 0.107	0.8±0.709 0.006	0.37±0.368 0.011
5mm	mm (p value)	1.24±1.071 0.005	0.77±1.398 0.116	0.24±0.259 0.017	1.52±1.962 0.037	0.54±0.227 0	0.88±0.791 0.007
8mm	mm (p value)	1.2±0.874 0.002	0.33±0.231 0.001	0.58±0.518 0.006	1.04±1.151 0.019	0.81±0.917 0.021	0.42±0.27 0.001

TABLE.7. TOTAL HORIZONTAL LOSS: BUCCAL + PALATAL

Horizontal components	units	Mesial	Medium	Distal	Mean
2mm	mm (p value)	1.742±0.045 2.76	2.863±0.014 2.24	1.829±0.004 2.093	2.093±2.004 0.009
5mm	mm (p value)	1.187±0.006 1.31	1.406±0.016 1.14	1.031±0.007 1.259	1.259±0.624 0
8mm	mm (p value)	0.562±0.002 1.12	0.716±0.001 1	0.529±0 0.964	0.964±0.344 0

BONE LOSS IN PERCENTAGE

TABLE.8. HORIZONTAL BONE LOSS IN BUCCAL AND PALATAL SIDE

Horizontal components	B-ME	B-CE	B-DIS	Tot-BU	P-ME	P-CE	P-DIS	Tot-PA	TOT
2mm	31.00%	26.20%	41.70%	15.50%	15.90%	18.50%	22.60%	19.20%	24.60%
5mm	-90.15%	36.15%	27.40%	21.10%	32.15%	24.15%	15.70%	15.00%	26.10%
8mm	23.20%	40.90%	27.50%	34.70%	23.40%	38.90%	39.80%	36.00%	36.10%
Total	-12.03%	34.47%	32.20%	28.77%	23.87%	27.23%	31.03%	28.40%	28.93%

TABLE.9. TOTAL HORIZONTAL LOSS

Horizontal components	TOT-MESIAL	TOTA-CENTRAL	TOTAL-DISTAL	TOTAL
2mm	21.90%	19.60%	31.90%	24.60%
5mm	20.80%	24.00%	29.80%	26.10%
8mm	23.80%	42.20%	33.80%	36.10%
Total	22.17%	28.60%	31.83%	28.93%

TABLE.10. VERTICAL BONE LOSS

VERTICAL COMPONENTS	BUCCAL	CENTRAL	PALATAL	OVERALL
MESIAL- LOSS	32.15%	23.80%	20.40%	25.50%
MEDIUM-LOSS	22.00%	14.20%	33.00%	23.07%
DISTAL-LOSS	62.80%	26.70%	27.90%	39.13%
OVERALL	39.90%	21.60%	27.70%	29.73%

TABLE.11

For comparison Examiner (Since no difference proved). **Independent Samples Test**

VAR00004			Levene's Test for Equality of Variances		t-test for Equality of Means						
			F	Sig.	t	df	P value	Mean Difference	Std. Error Difference	95% CI of the Difference Lower	Upper
Buccal	mesial-Before	Equal variances assumed	.011	.921	.203	8	.845	.3200	1.58019	-3.32392	3.96392
		Equal variances not assumed			.203	7.978	.845	.3200	1.58019	-3.32570	3.96570
	medium-Before	Equal variances assumed	.000	.994	.017	8	.987	.0400	2.36131	-5.40520	5.48520
		Equal variances not assumed			.017	7.999	.987	.0400	2.36131	-5.40531	5.48531
	distal-Before	Equal variances assumed	.033	.860	.092	8	.929	.0800	.86510	-1.91493	2.07493
		Equal variances not assumed			.092	7.993	.929	.0800	.86510	-1.91524	2.07524
	mesial-After	Equal variances assumed	.002	.968	.070	8	.946	.0800	1.13816	-2.54459	2.70459
		Equal variances not assumed			.070	7.997	.946	.0800	1.13816	-2.54476	2.70476
	medium-After	Equal variances assumed	.049	.831	.165	8	.873	.2400	1.45038	-3.10458	3.58458
		Equal variances not assumed			.165	7.968	.873	.2400	1.45038	-3.10689	3.58689
	distal-After	Equal variances assumed	.105	.754	-.061	8	.953	-.0600	.99146	-2.34632	2.22632
		Equal variances not assumed			-.061	7.957	.953	-.0600	.99146	-2.34847	2.22847
Central	mesial-Before	Equal variances assumed	.150	.709	.240	8	.816	.1600	.66708	-1.37815	1.69815
		Equal variances not			.240	7.774	.817	.1600	.66708	-1.38610	1.70610

		assumed									
	medium-Before	Equal variances assumed	.065	.806	.015	8	.989	.0200	1.35218	-3.09814	3.13814
		Equal variances not assumed			.015	7.971	.989	.0200	1.35218	-3.10012	3.14012
	distal-Before	Equal variances assumed	.068	.800	-.126	8	.902	-.0800	.63246	-1.53845	1.37845
		Equal variances not assumed			-.126	7.940	.902	-.0800	.63246	-1.54037	1.38037
	mesial-After	Equal variances assumed	.002	.963	.147	8	.887	.1400	.95478	-2.06172	2.34172
		Equal variances not assumed			.147	7.986	.887	.1400	.95478	-2.06237	2.34237
	medium-After	Equal variances assumed	.000	1.000	.064	8	.951	.1000	1.57124	-3.52329	3.72329
		Equal variances not assumed			.064	8.000	.951	.1000	1.57124	-3.52315	3.72315
	distal-After	Equal variances assumed	.020	.891	-.401	8	.699	-.1200	.29900	-.80949	.56949
		Equal variances not assumed			-.401	7.979	.699	-.1200	.29900	-.80981	.56981
palatal	mesial-Before	Equal variances assumed	.015	.867	.082	8	.936	.1400	1.69794	-3.77546	4.05546
		Equal variances not assumed			.082	7.995	.936	.1400	1.69794	-3.77588	4.05588
	medium-Before	Equal variances assumed	.000	.984	-.054	8	.958	-.1000	1.84640	-4.35781	4.15781
		Equal variances not assumed			-.054	7.997	.958	-.1000	1.84640	-4.35811	4.15811
	distal-Before	Equal variances assumed	.080	.785	.242	8	.815	.3200	1.32416	-2.73352	3.37352
		Equal variances not assumed			.242	7.916	.815	.3200	1.32416	-2.73917	3.37917
	mesial-After	Equal variances assumed	.001	.982	.018	8	.986	.0200	1.11005	-2.53977	2.57977
		Equal variances not assumed			.018	7.999	.986	.0200	1.11005	-2.53980	2.57980

	medium-After	Equal variances assumed	.010	.922	-.032	8	.975	-.0400	1.23361	-2.88472	2.80472
		Equal variances not assumed			-.032	8.000	.975	-.0400	1.23361	-2.88472	2.80472
	distal-After	Equal variances assumed	.028	.871	-.239	8	.817	-.1400	.58464	-1.48817	1.20817
		Equal variances not assumed			-.239	7.997	.817	-.1400	.58464	-1.48827	1.20827

Intraclass Correlation Coefficients
Two-Way Mixed Effects Model (Consistency Definition)

Measure	ICC Value	95% Confidence Interval Lower Bound	Upper Bound	F-Value	Sig.
Single Rater	.9874	.9628	.9957	157.1913	.0000
Average of Raters	.9936	.9811	.9979	157.1913	.0000

Degrees of freedom for F-tests are 14 and 14. Test Value = 0.

Inter correlation coefficients

Mesial-Before Pearson Correlation .989

Sig. (2-tailed) . .000

N 15 15

FIG.46. VERTICAL LOSS

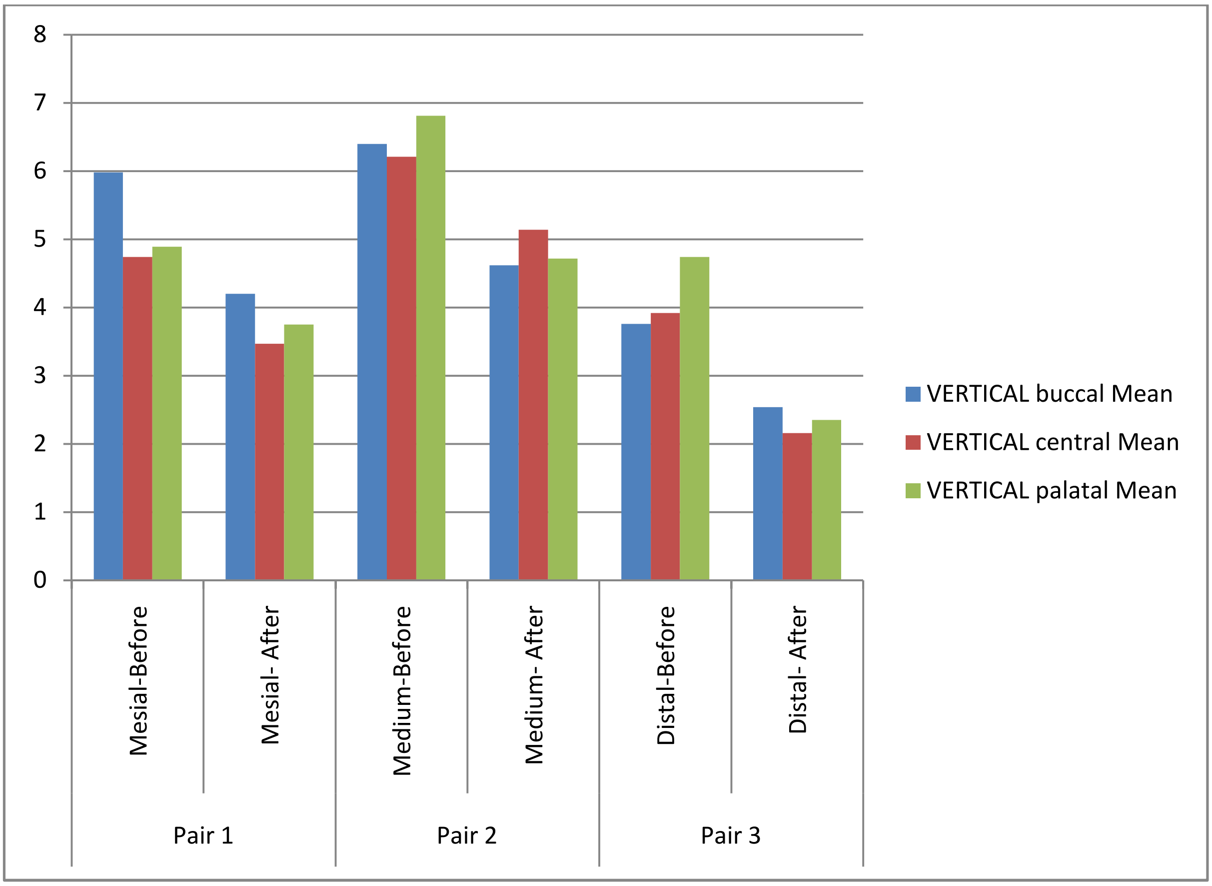


FIG.47.TOTAL HORIZONTAL LOSS: BUCCAL + PALATAL

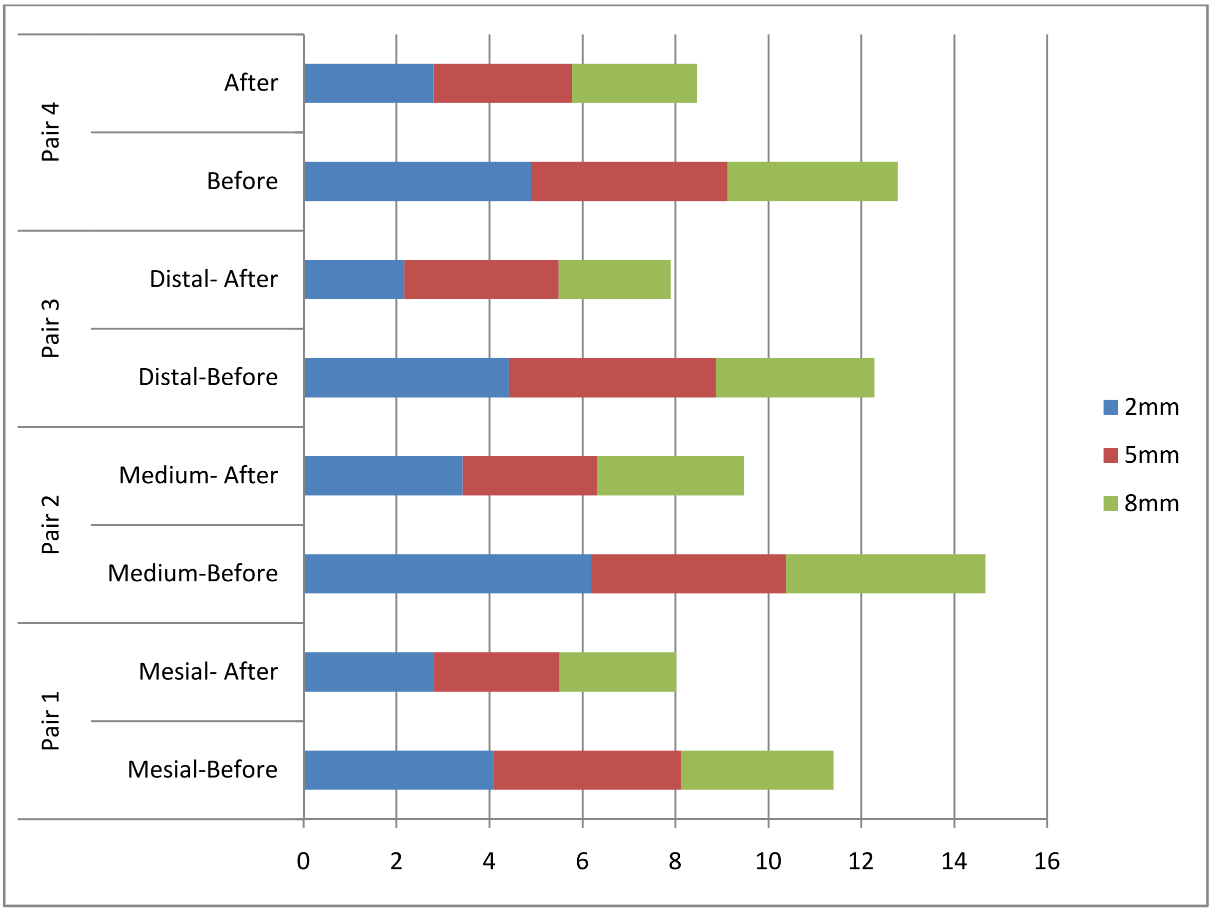
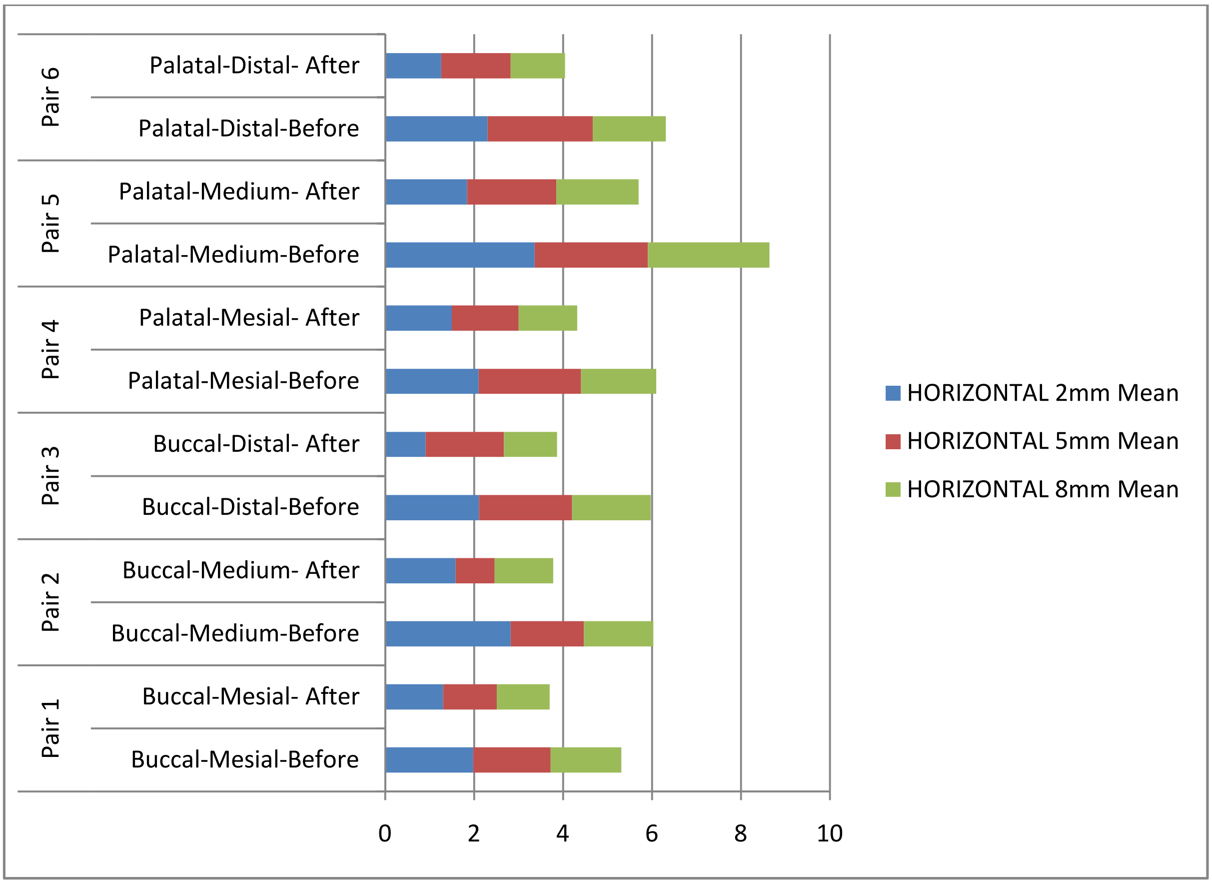


FIG.48. BUCCAL AND PALATAL LOSS



The current study was done in the Department of Periodontics, Sri Ramakrishna Dental College and Hospital, Coimbatore from Jun 2015 to Nov 2015, in this study, socket preservation procedure was evaluated in five extraction sites by the radiographic method.

A growing number of clinical and pre-clinical studies report on extraction socket management. According to several reports, the typical bone remodelling after tooth extraction[1,4] is limited when socket-preservation procedures using biomaterials are applied.[1,63] Nevertheless, many techniques and biomaterials have been studied and, because of the heterogeneity of the assessment methodologies, there is no evidence to support the superiority of one technique over another.[64,67] The objective of this study was to draw a map of bone remodelling patterns after alveolar ridge preservation procedures.

Because of the advances in digital oral imaging and decrease in radiation doses, a radiographic approach for analysis was considered in this study. The CT was preferred to Cone Beam Computed Tomography (CBCT), as the current CBCT technology has limitations related to the ‘‘cone-beam’’ projection geometry, detector sensitivity, and contrast resolution that produces images that lack the clarity and usefulness of conventional CT images. The clarity of CBCT images is affected by artifacts and poor soft tissue contrast.[68]

The use of CT scans to evaluate post-extraction ridge alterations has already been described by several authors.[64,65] However, in these studies, the real dimensional changes of the alveolar crest were not assessed. The results were analysed to determine the adequacy of the bone for placement of a dental implant; 6 mm was used as the minimal dimension required placing an implant. The outcomes of using this approach might be influenced by tooth location, and it is difficult to accurately compare them to the currently available data in the literature. Nevertheless, significant variations between the subjects were observed.

In contrast with most studies in which a single measurement of horizontal loss was recorded, our assessment method has the advantage of drawing a real map of the ridge alterations and highlighting a non-uniform bone remodelling throughout the treated area. Only two other studies[69,70] have proposed a similar measuring protocol to describe the post-surgical changes in both alveolar height and width. Nevertheless, these reports considered extraction socket overbuilding (GBR procedures), and the measurements were obtained during the surgeries.

In contrast, the radiographic protocol proposed here to assess hard tissue profile changes has the advantage of allowing less traumatic surgical procedures. Large flaps are no longer necessary to measure the alveolar crest dimensions. The proposed radiographic analysis proved to be reproducible and reliable because no significant difference was observed between the inter and intra-observer effects with respect to the radiographic measurements.

Post-extraction bone volume changes occur mostly during the first 3 months after extraction, but it has been reported in the literature that the remodelling continues for up to 12 months.[16] Nevertheless, the resorption pattern following socket-preservation procedures remains unknown. Therefore, the results of this study should be reviewed carefully because the follow- up assessment was performed at 3 months.

In this study, the mean (buccal & palatal) horizontal reduction in the ridge reached 2.093mm at the cervical level after the three months of socket preservation procedures, which is slightly higher (1.6mm) than the study results of *Lambert et al* 2012.[7] Both studies follow the same radiographic methodology for assessment of ridge remodelling pattern. And this total horizontal loss is lower than the 3.87mm and 4.3mm clinical loss in width after simple extraction studies in humans, described by *Weijden et al* and *Barone et al* respectively.[1,51]

The observations of this study showed that the total alveolar bone loss after three months of socket preservation procedure was about 29.3%. According to a study done by *Schropp et al*[16], it was reported that resorption after tooth removal may reduce ridge width by

50% and most changes occur within first 3 months. Intra-socket grafts seem to be unsuitable to reach the ultimate goal of complete ridge preservation, but was able to reduce the amount of resorption compared with spontaneous healing.[4,5,30]

In this study, comparing buccal and palatal side bone loss, buccal side (39.90%) showed more bone loss than palatal side (27.7%). This observed bucco-palatal alterations are similar to the findings of socket preservation study in *Lambert et al*[7] and also in several animal studies.[13,30,31] Horizontal buccal bone resorption has been shown to reach as much as 56% and the lingual bone resorption has been reported to be up to 30%, during the 4-month interval following tooth extraction alone.[39]

This present study showed that bone resorption progressively increased from cervical to apical level. In this study, bone resorption in percentage at 2mm level was 24.60%, 5mm level was 26.10%, 8mm level was 36.10%. But in contrast the study of *Lambert et al* showed that bone resorption was maximum in cervical region and progressively decreased towards the apical region. In the same study bone resorption in percentage at 2mm level was 23.9%, 5mm level was 10.5%, 8mm level was 5.77%.[7]

This study showed distal side bone loss (39.13%) was greater than mesial side bone loss (25.50%) based on the vertical components. The above finding was similar with the study results of *Simon et al*,[69] which showed that loss of augmented height was more in distal side (76.3%) than the mesial side (60.5%). But in contrast, the study of *Lambert et al*[7], there was no statistical significance between mesial and distal side alveolar bone loss.

Exposure of the bone during flaps is associated with osteoclast activation and bone resorption varying from 0.4 mm to 0.6 mm.[71] From aesthetic point of view, buccal bone loss appears to be crucial. So more bone loss were seen during full thickness flap elevation. Some authors[71-73] suggest that less marginal bone resorption and less osteoclastic activity is found when a partial thickness flap was used or when a coronal advanced flap was avoided. The surgical technique performed in this study was full thickness flap elevation with coronally advanced flap, may have resulted in greater than 2mm bone loss, in the cervical region which could be due to full reflection of the periosteum. *Lambert et al* performed partial thickness flap in his study, resulted in less than 1mm loss in the cervical region after three months of socket preservation procedure.

The socket preservation technique in this study used xenograft and RD as a non-resorpable membrane. No post-operative complications occurred and adequate healing was found.

The main advantages of RD membranes seem to be associated with their abilities to intimate adaptation and to seal off the surgical regenerative sites from oral fluids and bacteria in addition, several adjacent defect environments can be easily treated with just one membrane.[44]

The disadvantage of the RD membrane, which is the lack of tissue integration, connective tissue not attaching to the rubber dam, so the growth of the epithelium occurring underneath the flap, were also encountered in this study.[44]

The limitations of the present study were lack of control group and no other modality other than CT scan was applied to assess alveolar bone remodelling patterns. And also this was not compared with any other conventional radiographic methods.

The current study was done in the Department of Periodontics, Sri Ramakrishna Dental College and Hospital, Coimbatore from Jun 2015 to Nov 2015. In this study, socket preservation procedure was evaluated in five extraction sites by radiographic method (CT scan). The objective of this study was to draw a map of bone remodelling patterns after alveolar ridge preservation procedures.

This study analyses bone remodeling pattern, after socket preservation procedure with the help of CT scan. It also enables us to study the 3D radiographic pictures at the different level. Extraoral screen and customized templates were used for radiographic standardization.

3D radiographic analysis appears to be effective for assessing dimensional changes in alveolar bone after socket-preservation therapies. This type of analysis allowed a reproducible mapping of the hard tissue dimensional changes without any surgical trauma. This methodology assessed the quantitative bone loss after the socket preservation procedures.

It was observed that the remodelling of the alveolar process was not uniform after the socket preservation, and a complete inhibition of the bone remodelling was not achieved during alveolar socket preservation procedures.

The following conclusions were drawn from this study:

1. Total loss of alveolar bone is about 29.3%, three months following socket preservation procedures.
2. For the horizontal component, alveolar bone loss was greater in the apical region (36.1% at 8 mm level), moderate in the middle (26.80% at 5mm level) and low in the cervical region (24.60% at 2 mm level).
3. For the vertical component, buccal side alveolar bone loss (39.9%) was greater than the palatal side alveolar bone loss (27.7%), and distal side alveolar bone loss (39.13%) was greater than mesial side alveolar bone loss (25.50%).

4. Among all values, Disto- buccal alveolar bone loss was highest (62.80%).

The limitations of the present study were the lack of control group and no other modality other than CT scan was applied to assess alveolar bone remodelling patterns. Also the results obtained were not compared with any other conventional radiographic methods.

As modern technology is developing at a rapid rate, in future it is possible to obtain better methods for assessment of remodelling patterns of alveolar bone.

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